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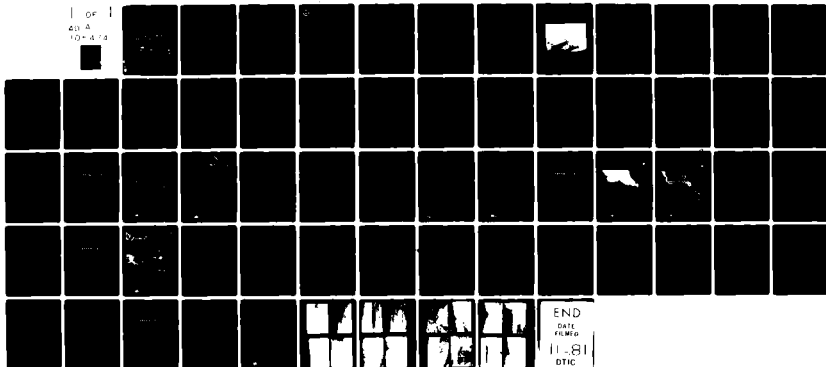
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MISSISSIPPI-KASKASKIA-ST. LOUIS RIVER BASIN

LAKENAN LAKE DAM

PERRY COUNTY, MISSOURI

MO 31066

PHASE 1 INSPECTION REPORT NATIONAL DAM SAFETY PROGRAM



United States Army
Corps of Engineers

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St. Louis District

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OCT 14 1981

PREPARED BY: U.S. ARMY ENGINEER DISTRICT, ST. LOUIS

FOR: STATE OF MISSOURI

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MARCH, 1981

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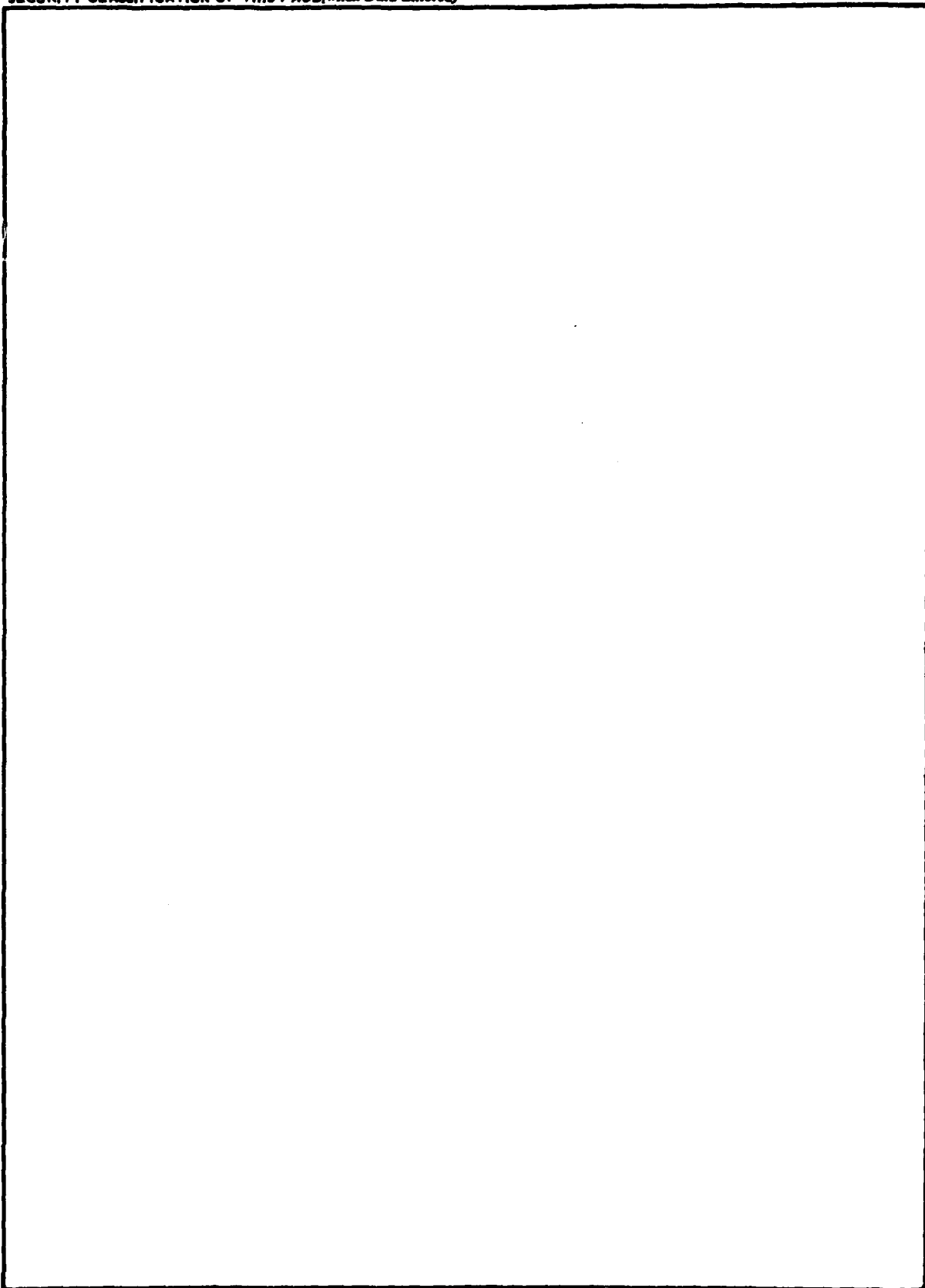
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MISSISSIPPI-KASKASKIA-ST. LOUIS RIVER BASIN

LAKENAN LAKE DAM

PERRY COUNTY, MISSOURI

MISSOURI INVENTORY NO. 31066

PHASE 1 INSPECTION REPORT
NATIONAL DAM SAFETY PROGRAM

Prepared By

Anderson Engineering, Inc., Springfield, Missouri
Hanson Engineers, Inc., Springfield, Illinois

Under Direction Of

St. Louis District, Corps of Engineers

For

Governor of Missouri

March 1981

PHASE 1 REPORT
NATIONAL DAM SAFETY PROGRAM
SUMMARY

Name of Dam:	Lakenan Lake Dam
State Located:	Missouri
County Located:	Perry
Stream:	Tributary of Blue Spring Branch
Date of Inspection:	19 December 1980

Lakenan Lake Dam was inspected by an interdisciplinary team of engineers from Anderson Engineering, Inc. of Springfield, Missouri and Hanson Engineers, Inc. of Springfield, Illinois. The purpose of the inspection was to make an assessment of the general condition of the dam with respect to safety, based upon available data and visual inspection, in order to determine if the dam poses hazards to human life or property.

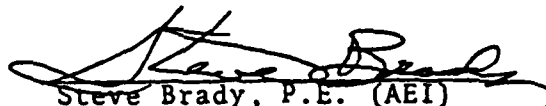
The guidelines used in the assessment were furnished by the Department of the Army, Office of the Chief of Engineers, and they have been developed with the help of several Federal and State agencies, professional engineering organizations, and private engineers. Based on these guidelines, the St. Louis District, Corps of Engineers has determined that this dam is in the high hazard potential classification, which means that loss of life and appreciable property loss could occur if the dam fails. The estimated damage zone extends approximately two miles downstream of the dam. Located within this zone are the village of Lithium (several dwellings) and a dwelling and 2 trailers (0.3 miles downstream of Lithium). The existence of these downstream features was verified during the field inspection and at the time the aerial photographs were taken. The dam is in the small size classification, since it is greater than 25 ft high but less than 40 ft high, and the maximum storage capacity is greater than 50 acre-ft but less than 1,000 acre-ft.

Our inspection and evaluation indicates that the combined spillways do not meet the criteria set forth in the guidelines for a dam having the above size and hazard potential. The combined spillways will pass 25 percent of the Probable Maximum Flood without overtopping. The Probable Maximum Flood is defined as the flood discharge that may be expected from the most severe combination of critical meteorologic and hydrologic conditions that are reasonably possible in the region. The guidelines require that a dam of small size with a high downstream hazard potential pass 50 to 100 percent of the PMF. Considering the low height of the dam and the small storage capacity, 50 percent of the PMF has been determined to be the appropriate spillway design flood.


The 1 percent probability flood will not overtop the dam. The 1 percent probability flood is one that has a 1 percent chance of being exceeded in any given year.

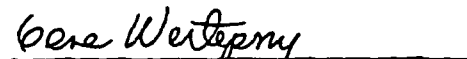
The dam is generally in good condition. Deficiencies visually observed by the inspection team were: (1) lack of wave protection for the upstream face; (2) erosion of the bank in the approach to the emergency spillway; (3) animal holes in the upstream face; and (4) erosion at the downstream abutment-dam contacts. Another deficiency was the lack of seepage and stability analysis records.

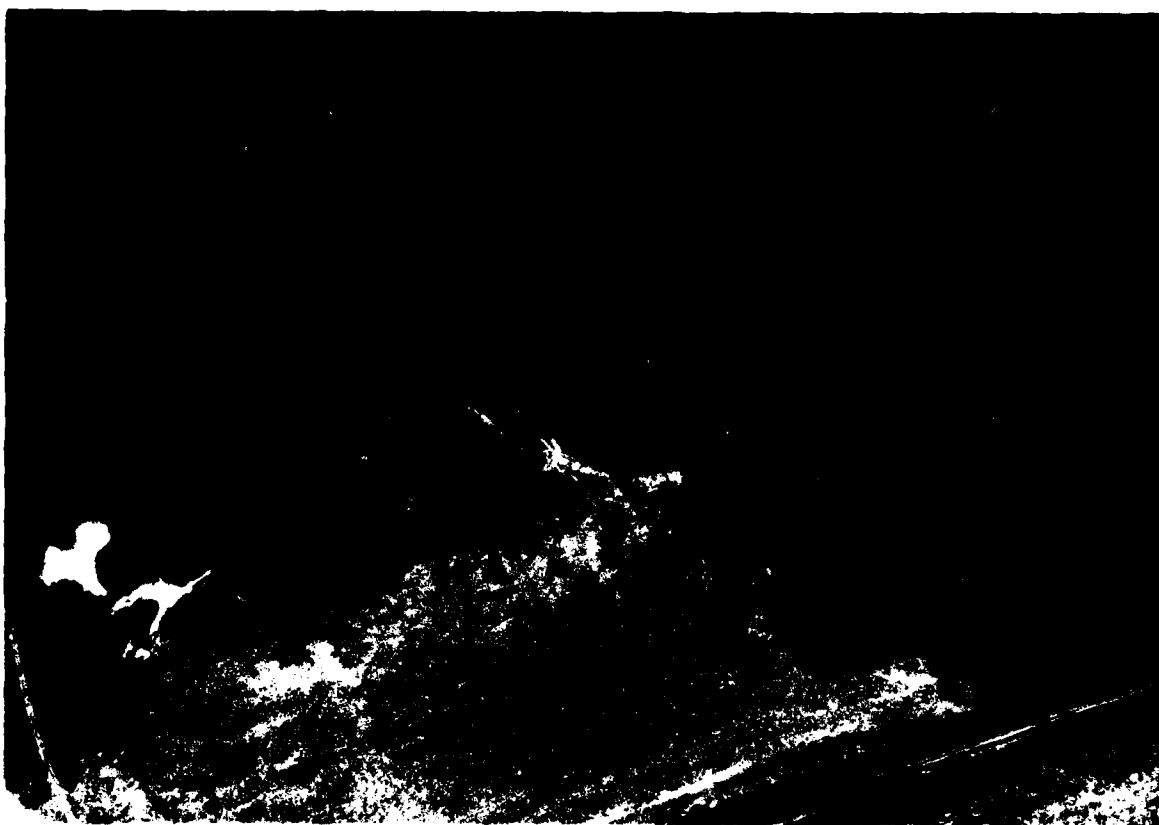
It is recommended that the owners take the necessary action promptly to correct the deficiencies reported herein. A detailed discussion of these deficiencies is included in the following report.


Steve Brady, P.E. (AEI)


Tom Beckley, P.E. (AEI)


Dave Daniels, P.E. (HEI)


Gene Wertepny, P.E. (HEI)



AERIAL VIEW OF LAKE AND DAM

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SECTION 1 - PROJECT INFORMATION

1.1 GENERAL:

A. Authority:

The National Dam Inspection Act, Public Law 92-367, authorized the Secretary of the Army, through the Corps of Engineers, to initiate a program of safety inspection of dams throughout the United States. Pursuant to the above, the St. Louis District, Corps of Engineers, District Engineer directed that a safety inspection be made of Lakenan Lake Dam in Perry County, Missouri.

B. Purpose of Inspection:

The purpose of the inspection was to make an assessment of the general condition of the dam with respect to safety, based upon available data and a visual inspection in order to determine if the dam poses hazards to human life or property.

C. Evaluation Criteria:

Criteria used to evaluate the dam were furnished by the Department of the Army, Office of the Chief of Engineers, "Recommended Guidelines for Safety Inspection of Dams, Appendix D." These guidelines were developed with the help of several federal agencies and many state agencies, professional engineering organizations, and private engineers.

1.2 DESCRIPTION OF PROJECT:

A. Description of Dam and Appurtenances:

Lakenan Lake Dam is an earth fill structure approximately 29 ft high and 300 ft long at the crest. In this report, right and left orientation is based on looking in the downstream direction. The appurtenant works consist of a drop inlet and pipe principal spillway and a 1 1/2 in. plastic watering pipe through the dam. An earth swale emergency spillway is located in the left abutment.

B. Location:

The dam is located in the northwest part of Perry County, Missouri on a tributary of Blue Spring Branch. The dam and lake are within the Lithium, Missouri 7.5 minute quadrangle sheet -latitude 37 deg. 49.6

min. , longitude 89 deg. 53.4 min.). Sheet 2 of Appendix A shows the general vicinity.

C. Size Classification:

With an embankment height of 29 ft and a maximum storage capacity of approximately 105 acre-ft, the dam is in the small size category.

D. Hazard Classification:

The St. Louis District, Corps of Engineers has determined that this dam is in the high hazard potential classification. The estimated damage zone extends approximately two miles downstream of the dam. Located within this zone are the village of Lithium (several dwellings) and a dwelling and two trailers (0.3 miles downstream of Lithium). The existence of these downstream features was verified during the field inspection and at the time the aerial photographs were taken.

E. Ownership:

The dam is owned by James Lakenan. The owner's address is Rte 3, Perryville, Missouri, 63775 (telephone:314-547-6763).

F. Purpose of Dam:

The dam was constructed primarily for recreation.

G. Design and Construction History:

The dam was constructed in 1966 by a Mr. Wallenmeyer of Jackson, Missouri. The Soil Conservation Service of Perryville, Missouri provided design assistance. The owner, who was employed by SCS at the time, was on the site during construction. The owner indicated that the material for the dam was taken from the left abutment area and that a cutoff trench was constructed, but he couldn't recall the depth of the cutoff. Design plans provided by the Soil Conservation Service indicate that the cutoff trench was to be 12 ft wide with an average depth of 5 ft. No modifications have been made to the dam. Another dam (MO I.D. No. 31067) is located approximately 1,500 ft upstream of the Lakenan Dam. The effect of the upper dam was considered in the routing analysis as explained in Section 5 of the text and in Appendix C. Further information on the upper dam (Ellis Lake Dam) can be obtained from the Phase I inspection report for that dam dated February 1981.

H. Normal Operating Procedures:

Normal flows are discharged over the uncontrolled principal and emergency spillways. A 1 1/2 in. diameter flexible plastic pipe is used periodically for watering purposes by lowering the inlet end into the lake (there are no valves on the pipe). The owner reported that the maximum lake level occurred in 1974 when the water was approximately 6 in. above the crest of the emergency spillway.

1.3 PERTINENT DATA:

Pertinent data about the dam, appurtenant works, and reservoir are presented in the following paragraphs. Sheet 3 of Appendix A presents a plan, profile, and typical section of the embankment.

A. Drainage Area:

The drainage area for this dam, as obtained from the USGS quad sheet, is approximately 200 acres.

B. Discharge at Dam Site:

- (1) All discharge at the dam site is through uncontrolled spillways.
- (2) Estimated Total Spillway Capacity at Maximum Pool (Top of Dam - El. 413.7): 400 cfs
- (3) Estimated Capacity of Primary Spillway: 16 cfs
- (4) Estimated Experienced Maximum Flood at Dam Site: 35 cfs
- (5) Diversion Tunnel Low Pool Outlet at Pool Elevation: Not Applicable
- (6) Diversion Tunnel Outlet at Pool Elevation: Not Applicable
- (7) Gated Spillway Capacity at Pool Elevation: Not Applicable
- (8) Gated Spillway Capacity at Maximum Pool Elevation: Not Applicable

C. Elevations:

All elevations are consistent with an assumed mean sea level elevation of 409.0 for the crest of the principal spillway (estimated from quadrangle map).

- (1) Top of Dam: 413.7

- (2) Principal Spillway Crest: 409
- (3) Emergency Spillway Crest: 411
- (4) Principal Outlet Pipe Invert: 390.5
- (5) Streambed at Centerline of Dam: 384.6
- (6) Pool on Date of Inspection: 407.2
- (7) Apparent High Water Mark: Not Evident
- (8) Maximum Tailwater: Unknown
- (9) Upstream Portal Invert Diversion Tunnel: Not Applicable
- (10) Downstream Portal Invert Diversion Tunnel: Not Applicable

D. Reservoir Lengths:

- (1) At Top of Dam: 1,425 ft
- (2) At Principal Spillway Crest: 1,400 ft
- (3) At Emergency Spillway Crest: 1,410 ft

E. Storage Capacities:

- (1) At Principal Spillway Crest: 69 acre-ft
- (2) At Top of Dam: 105 acre-ft
- (3) At Emergency Spillway Crest: 82 acre-ft

F. Reservoir Surface Areas:

- (1) At Principal Spillway Crest: 6.0 acres
- (2) At Top of Dam: 9.5 acres
- (3) At Emergency Spillway Crest: 7.1

G. Dam:

- (1) Type: Earth
- (2) Length at Crest: 300 ft

- (3) Height: 29 ft
- (4) Top Width: 10 ft
- (5) Side Slopes: Upstream Varies, 2.8H:1V to 4H:1V to water surface, Downstream Varies, 2.1H:1V to 2.7H:1V
- (6) Zoning: None
- (7) Impervious Core: None
- (8) Cutoff: 5 ft deep; 12 ft wide(from plans)
- (9) Grout Curtain: None

H. Diversion and Regulating Tunnel:

- (1) Type: Not Applicable
- (2) Length: Not Applicable
- (3) Closure: Not Applicable
- (4) Access: Not Applicable
- (5) Regulating Facilities:

I. Spillway:

I.1 Principal Spillway:

- (1) Location: Station 1+40
- (2) Type: 18 in. diam. CMP riser; 15 in. diam. pipe through dam.

I.2 Emergency Spillway:

- (1) Location: Left abutment
- (2) Type: Trapezoidal earth cut, 20 ft bottom width and 6H:1V, approximate, side slopes

J. Regulating Outlets: None

SECTION 2 - ENGINEERING DATA

2.1 DESIGN:

The Soil Conservation Service provided design assistance for this dam. Information provided by SCS consisted of (1) a plan sheet showing the lake and drainage areas with hydraulic design data and materials quantities; (2) a sheet showing a cross section of the dam at the location of the principal spillway and a cross section along the centerline of fill; (3) a geologic investigation including conclusions and recommendations (included as Sheets 4 and 5 of Appendix B); (4) field notes from a seismic survey made at the dam site; and (5) miscellaneous survey notes.

A. Surveys:

Surveys were made by SCS previous to construction for the purpose of obtaining storage and embankment quantities. Sheet 3 of Appendix A presents a plan, profile, and cross section of the dam from survey data obtained during our site inspection. Sheet 4 of Appendix A shows a section and profile of the emergency spillway. The top of the principal spillway pipe riser was used as a reference point to determine all other elevations. It is estimated that this site datum corresponds to mean sea level (MSL) elevation 409.0 (estimated from quad sheet).

B. Geology and Subsurface Materials:

The site is located in the east-central portion of the Ozarks geologic region of Missouri. The Ozarks are characterized topographically by hills, plateaus, and deep valleys. The most common bedrock types are dolomite, sandstone, and chert. The "Geologic Map of Missouri" indicates that the bedrock in the site area consists of the Joachim Formation. The Joachim is predominantly a yellowish-brown, argillaceous dolomite which contains limestone and shale in its lower part. As indicated by the SCS geologic report (Sheets 4 and 5 of Appendix B), there are numerous sinkholes in the area.

The "Geologic Map of Missouri" indicates several normal faults passing just north of the site in an east-west direction. It should also be noted that the site is located in seismic zone 2 (moderate damage zone) but is close to the boundary of zone 3 (major damage zone - see Sheet 3 of Appendix B).

The seismic survey made by SCS indicated about 18 ft to 20 ft of soil overburden in the left abutment and valley areas, while the right abutment had very thin soil cover, with the Joachim Dolomite outcropping near the base of the valley. The soils are of the Memphis-Loring Soil Association and have developed from fairly thick loess deposits (see Loessial Thickness map, Sheet 2 of Appendix B). Auger probes in the embankment indicate the soils to be brown clayey silts to silty clays (ML-CL). These soils would be considered to be fairly erodible.

C. Foundation and Embankment Design:

No foundation or embankment design information was available. Seepage and stability analyses required by the guidelines were not available. The owner indicated that borrow for the dam was obtained from the left abutment areas. He indicated that a cutoff was incorporated, and the design plans by SCS called for a 12 ft wide by 5 ft deep cutoff.

D. Hydrology and Hydraulics:

Hydrology and hydraulics information as listed in Section 2.1 was obtained from SCS. This information was incorporated into our analyses. Based on this information, a field check of spillway dimensions and embankment elevations, and a check of the drainage area on the USGS quad sheet, hydrologic analyses using U.S. Army Corps of Engineers guidelines were performed and appear in Appendix C.

E. Structures:

The only appurtenant structures associated with this dam are the principal spillway riser and pipe and the 1 1/2 in. plastic watering pipe. The SCS plans called for two antiseep collars at about the 1/4 and 1/2 points along the pipe (starting at the inlet end).

2.2 CONSTRUCTION:

The owner was employed by SCS at the time the dam was built and was on the site during construction. However, no inspection data were available.

2.3 OPERATION:

Normal flows are passed by uncontrolled spillways. There are no operating facilities.

2.4 EVALUATION:

A. Availability:

The engineering data available are as listed in Section 2.1 No seepage or stability analyses, or construction test data were available.

B. Adequacy:

The engineering data available were inadequate to make a detailed assessment of the design, construction, and operation of this structure. Seepage and stability analyses comparable to the requirements of the "Recommended Guidelines for Safety Inspection of Dams" were not available, which is considered a deficiency. These seepage and stability analyses should be performed for appropriate loading conditions (including earthquake loads) and made a matter of record.

C. Validity:

To our knowledge, no valid engineering data on the design or construction of the embankment are available.

SECTION 3 - VISUAL INSPECTION

3.1 FINDINGS:

A. General:

The field inspection was made on 19 December 1980. The inspection team consisted of personnel from Anderson Engineering, Inc. of Springfield, Missouri and Hanson Engineers, Inc. of Springfield, Illinois. The team members were:

Steve Brady - Anderson Engineering, Inc. (Civil Engineer)
Tom Beckley - Anderson Engineering, Inc. (Civil Engineer)
Gene Wertepny - Hanson Engineers, Inc. (Hydraulic Engineer)
Dave Daniels - Hanson Engineers, Inc. (Geotechnical Engineer)

Photographs of the dam, appurtenant structures, reservoir, and downstream features are presented in Appendix D.

B. Dam:

The dam appears to be in good condition. The upstream face is grass covered and without wave protection (see Photo No. 5). There are a few small animal holes, but no significant erosion.

The crest of the dam is clear and mowed. It appeared uniform both vertically and horizontally, and no cracking or unusual movement was observed (see Photo No. 4). The downstream face is grass covered and clear of trees and brush (see Photos 6 and 7). No sloughing or seepage was noted. An erosion gully was noted at the left downstream dam-abutment contact near the outlet of the principal spillway pipe. Some minor erosion was also noted at the right downstream dam-abutment contact.

Auger probes in the embankment indicated a brown clayey silt (ML-CL).

C. Appurtenant Structures:

C.1 Principal Spillway:

The principal spillway consists of an 18 in. corrugated metal pipe drop inlet which is coated with asphalt. The riser has a 5 ft by 26 in. antivortex wall of asphalt coated corrugated metal bolted to it. The riser is surrounded by a reinforcing bar trash rack (see Photos 8

and 9). Connected to the riser at its base is a 15 in. diameter asphalt coated corrugated metal pipe which goes through the dam and empties into an unlined plunge pool at the toe of the dam (see Photos 10 and 11). The spillway riser and outlet pipe appear in good condition. Fairly significant erosion has occurred in the plunge pool area at the end of the pipe.

A 1 1/2 in. flexible plastic pipe also goes through the dam at this location. This pipe is used for watering purposes by lowering the inlet end of the pipe into the lake (see Photos 11 and 15).

C.2 Emergency Spillway:

The emergency spillway is a trapezoidal earth cut in the left abutment. Discharges are directed away from the dam by a low berm on the right side. The bank of the lake at the entrance to the emergency spillway is severely eroded. The discharge channel is grass covered and has not been significantly eroded. The spillway is clear of trees and brush and has a low wire fence across it which is a remnant of a fence used formerly for retaining cattle (see Photos 12, 13, and 14).

D. Reservoir:

The watershed is primarily wooded with moderate slopes. A large portion of the watershed is controlled by the upper dam previously mentioned. The slopes adjacent to Lakenan Lake are moderate, and no sloughing or serious erosion was noted. No significant sedimentation was observed.

E. Downstream Channel:

The downstream channel is fairly well defined and heavily wooded immediately downstream of the dam.

3.2 EVALUATION:

The lack of wave protection could cause erosion and sloughing of the upstream face with time. The animal holes, if not filled, could eventually be sources of leakage through the dam. The erosion noted could become serious and could affect the structural stability of the dam if not repaired and maintained.

SECTION 4 - OPERATIONAL PROCEDURES

4.1 PROCEDURES:

There are no operating facilities. The pool is normally controlled by rainfall, runoff, and the capacity of the uncontrolled spillways.

4.2 MAINTENANCE OF DAM:

The embankment is clear of trees and brush, so it is evident that some maintenance is done.

4.3 MAINTENANCE OF OPERATING FACILITIES:

There are no operating facilities.

4.4 DESCRIPTION OF ANY WARNING SYSTEM IN EFFECT:

The inspection team is unaware of any existing warning system for this dam.

4.5 EVALUATION:

The lack of riprap, eroded areas, and animal holes could become serious if not corrected. A regular program of maintenance should be established.

SECTION 5 - HYDRAULIC/HYDROLOGIC

5.1 EVALUATION OF FEATURES:

A. Design Data:

The Soil Conservation Service provided some hydrologic and hydraulic design data for this dam. The drainage area, and the lake area, storage and elevation relationships, as provided by SCS, were used in our analyses.

B. Experience Data:

No recorded rainfall, runoff, discharge, or reservoir stage data were available for this lake and watershed. The owner of the dam indicated that the maximum water level was approximately 6 in. above the crest of the emergency spillway in 1974.

C. Visual Observations:

The principal spillway appears to be in good condition. The emergency spillway outlet channel is well separated from the embankment by an earth berm, and spillway releases would not be expected to endanger the dam.

D. Overtopping Potential:

The hydraulic and hydrologic analyses (using the U.S. Army Corps of Engineers guidelines and the HEC-1 computer program) were based on: (1) a field survey of spillway dimensions and embankment elevation, and (2) an estimate of the reservoir storage and the pool and drainage areas from the Lithium Missouri, 7.5 minute USGS quad sheet, and (3) storage and drainage area data provided by SCS.

Based on the hydrologic and hydraulic analysis presented in Appendix C, the combined spillways will pass 25 percent of the Probable Maximum Flood. The Probable Maximum Flood is defined as the flood discharge that may be expected from the most severe combination of critical meteorologic and hydrologic conditions that are reasonably possible in the region. The recommended guidelines from the Department of the Army, Office of the Chief of Engineers, require that this structure (small size with high downstream hazard potential) pass 50 percent to 100 percent of the PMF, without overtopping. Considering the low height of the dam and the small storage capacity, 50 percent of

the PMF has been determined to be the appropriate spillway design flood. The spillways will pass the 1 percent probability flood without overtopping the dam.

Application of the probable maximum precipitation (PMP), minus losses, resulted in a flood hydrograph peak inflow of 4,040 cfs. For 50 percent of the PMP, the peak inflow was 1,800 cfs.

The routing of the PMF through the spillways and dam indicates that the dam will be overtopped by 2.2 ft at elevation 415.9. The duration of the overtopping will be 5.6 hours, and the maximum outflow will be 3,670 cfs. The maximum discharge capacity of the spillways is 400 cfs. The routing of 50 percent of the PMF indicates that the dam will be overtopped by 1.2 ft at elevation 414.9. The maximum outflow will be 1,630 cfs, and the duration of overtopping will be 1.7 hours. Overtopping of an earthen embankment could cause serious erosion and could possibly lead to failure of the structure.

A large portion (143 acres) of Lakenan Lake Dam watershed is controlled by an upstream dam and reservoir. The upper dam is 28 ft high and 325 ft long. The upper reservoir surface area at normal pool is 4 acres and 7.3 acres at the top of dam. The upper reservoir storage is 45 acre-ft at normal pool and 71 acre-ft at the top of dam. The upper dam has two spillways with a maximum capacity of 150 cfs at the top of dam elevation. The downstream toe of the upper dam is about 4 ft below the normal pool elevation of Lakenan Lake Dam. For more detailed information about the upstream dam, refer to the 1981 Inspection Report for Ellis Lake Dam (MO 31067).

To consider the effect of the upper dam, the outflow hydrograph of the upper dam was combined with the inflow hydrograph of Lakenan Lake Dam (lower dam). Then, the combined hydrograph was routed through the lake and spillways of the lower dam.

The effect of the upper dam was studied, assuming that (1) the upper dam will resist the overtopping and (2) that the upper dam will breach during overtopping.

The routing study indicates that a breach of the upper dam will not significantly increase the overtopping potential of Lakenan Lake Dam.

The following parameters, as recommended by the St. Louis District Corps of engineers, were used in the breach analysis (\$B cards of input data, Sheet 12, Appendix C):

- 1) Breach bottom width = 10 ft

- 2) Side slope of breach (z) = 0.5H to 1.0V
- 3) Breach bottom elevation = 412.0
- 4) Failure time = 1/2 hr (Plan 1) and 1.0 hr (Plan 2)
- 5) Initial water surface elevation = 427.0 (Normal Pool)
- 6) Failure elevation = 434.35 (PMF Water Surface Elevation)

Failure elevation = 432.0 (top of dam) was also studied, but the result was less significant than assuming 434.35.

The computer input and a summary of the computer output for the breach analysis are shown on Sheets 12, 13, and 14 of Appendix C.

SECTION 6 - STRUCTURAL STABILITY

6.1 EVALUATION OF STRUCTURAL STABILITY:

A. Visual Observations:

Observed features which could adversely affect the structural stability of this dam are discussed in Sections 3.1.B and 3.2.

B. Design and Construction Data:

No design and construction data for the foundation and embankment were available. Seepage and stability analyses comparable to the requirements of the guidelines were not available, which constitutes a deficiency which should be rectified.

C. Operating Records:

No operating records have been obtained.

D. Post-Construction Changes:

There have been no post-construction changes to this dam.

E. Seismic Stability:

The structure is located in seismic zone 2. The guidelines assign a moderate seismic damage potential to this zone. It is recommended that the prescribed seismic loading for this zone be applied in stability analyses performed for this dam.

SECTION 7 - ASSESSMENT/REMEDIAL MEASURES

7.1 DAM ASSESSMENT:

This Phase I inspection and evaluation should not be considered as being comprehensive since the scope of work contracted for is far less detailed than would be required for an in-depth evaluation of dams. Latent deficiencies, which might be detected by a totally comprehensive investigation, could exist.

A. Safety:

The embankment is generally in good condition. Several items were noted during the visual inspection which should be corrected and controlled. These items are: (1) lack of wave protection for the upstream face; (2) erosion of the bank in the approach to the emergency spillway; (3) animal holes in the upstream face; and (4) erosion at the downstream abutment-dam contacts.

Another deficiency was the lack of seepage and stability analyses records.

The dam will be overtopped by flows in excess of 25 percent of the Probable Maximum Flood. Overtopping of an earthen embankment could cause serious erosion and could possibly lead to failure of the structure.

B. Adequacy of Information:

The conclusions in this report were based on review of the information listed in Section 2.1, the performance history as related by others, and visual observation of external conditions. The inspection team considers that these data are sufficient to support the conclusions herein. Seepage and stability analyses comparable to the "Recommended Guidelines for Safety Inspection of Dams" were not available, which is considered a deficiency.

C. Urgency:

The remedial measures recommended in paragraph 7.2 should be accomplished in the near future. If the deficiencies listed in paragraph 7.1.A are not corrected, and if good maintenance is not provided, the embankment condition will continue to deteriorate and possibly could become serious in the future. The items recommended in

paragraph 7.2.A should be pursued promptly.

D. Necessity for Additional Inspection:

Based on the result of the Phase I inspection, a Phase II inspection is not recommended.

E. Seismic Stability:

The structure is located in seismic zone 2. The guidelines assign a moderate seismic damage potential to this zone. It is recommended that the prescribed seismic loading for this zone be applied in any stability analyses performed for this dam.

7.2 REMEDIAL MEASURES:

The following remedial measures and maintenance procedures are recommended. All remedial measures should be performed under the guidance of a professional engineer experienced in the design and construction of dams.

A. Alternatives:

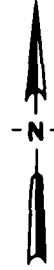
- (1) Spillway size and/or height of dam should be increased to pass 50 percent of the PMF. In either case, the spillway should be protected to prevent erosion.

B. O and M Procedures:

- (1) Seepage and stability analyses comparable to the requirements of the recommended guidelines should be performed by an engineer experienced in the construction of dams.
- (2) Wave protection should be provided for the upstream face of the dam.
- (3) Animal holes should be filled.
- (4) Eroded areas should be repaired and maintained.
- (5) A detailed inspection of the dam should be made periodically by an engineer experienced in the design and construction of dams.

APPENDIX A

Dam Location and Plans



KANSAS CITY

ST. LOUIS

Location
of Dam

LOCATION MAP

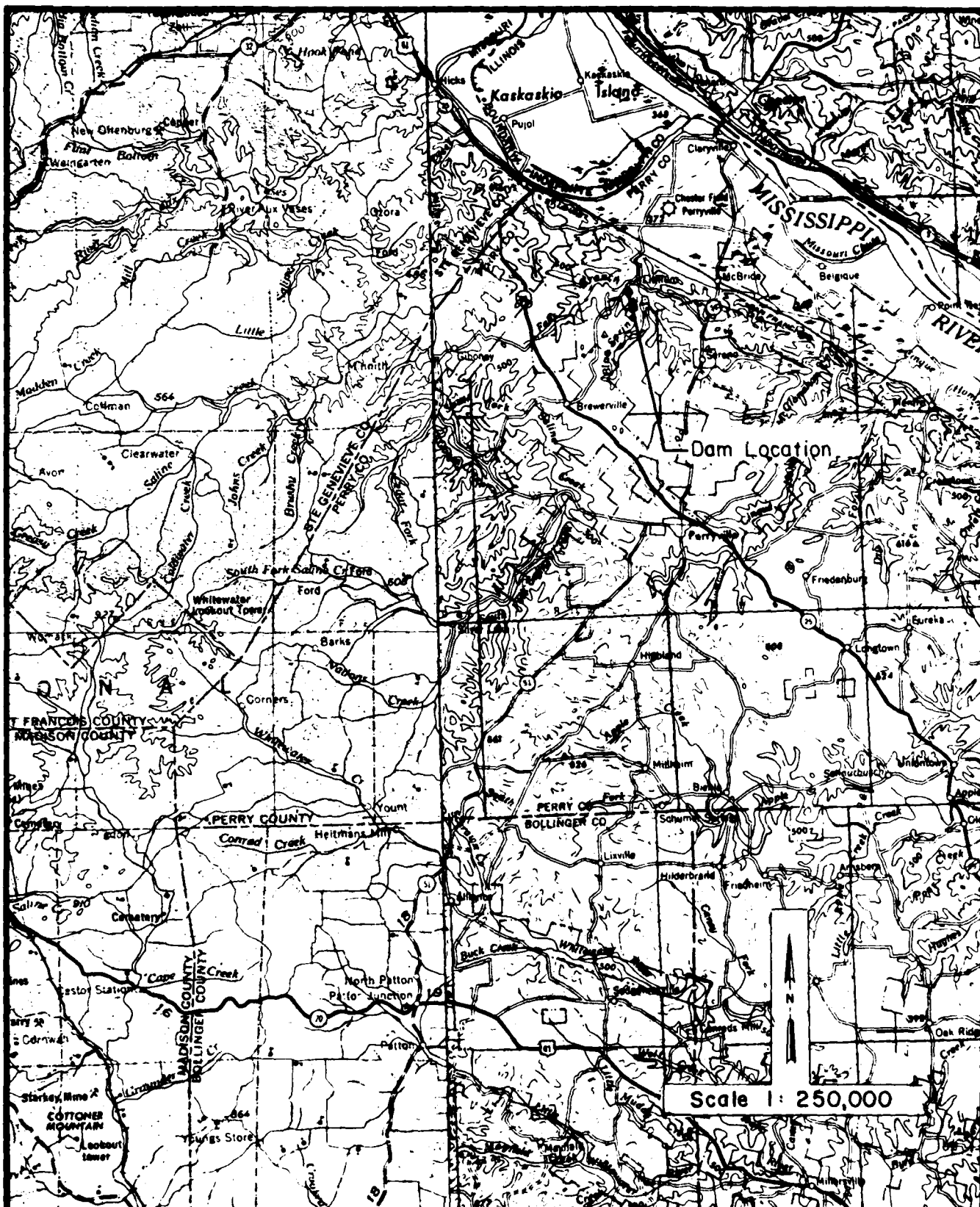


HANSON
ENGINEERS
INCORPORATED

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Lakenan Lake Dam
Perry County, Missouri
Mo. I.D. No. 31066

SHEET 1, APPENDIX A



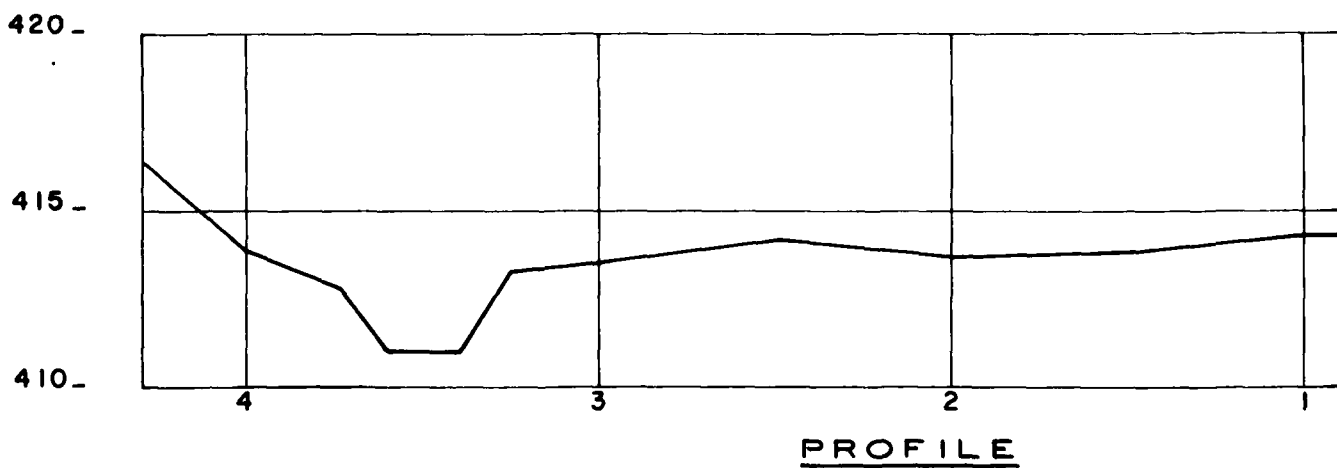
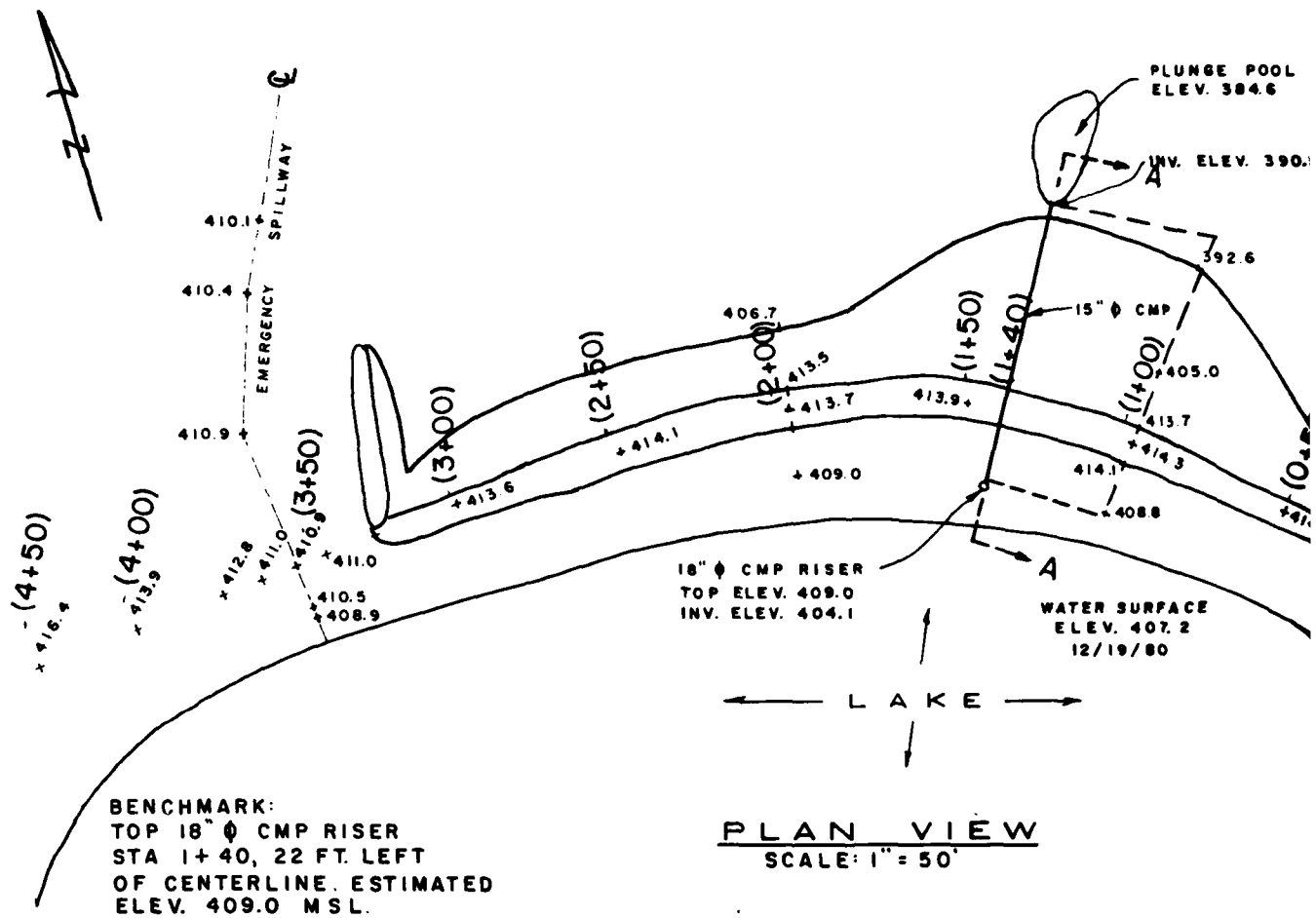
VICINITY MAP



SPRINGFIELD, IL • PEORIA, IL • ROCKFORD, IL

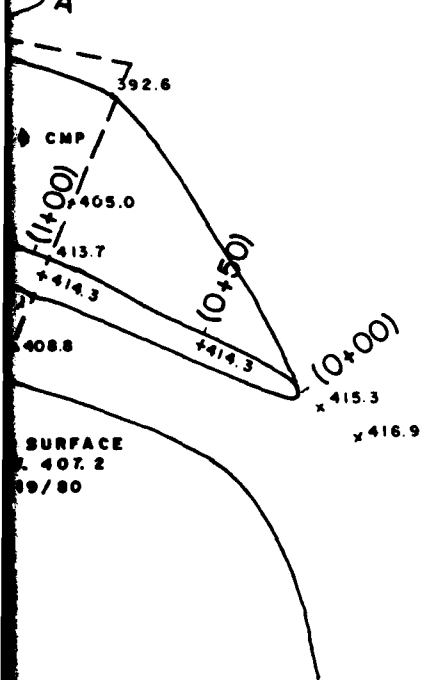
Lanken Lake Dam
Perry County, Missouri
Mo. I.D. No. 31066

Sheet 2, Appendix A



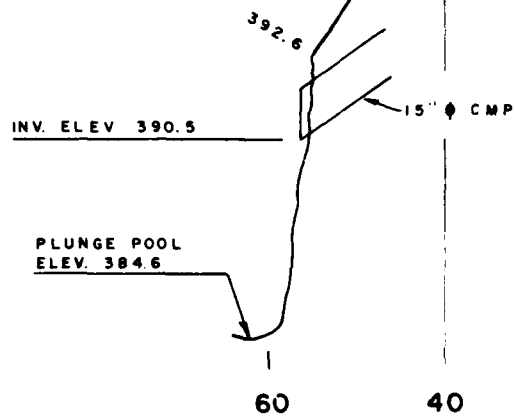
PLUNGE POOL
ELEV. 384.6

INV. ELEV. 390.5

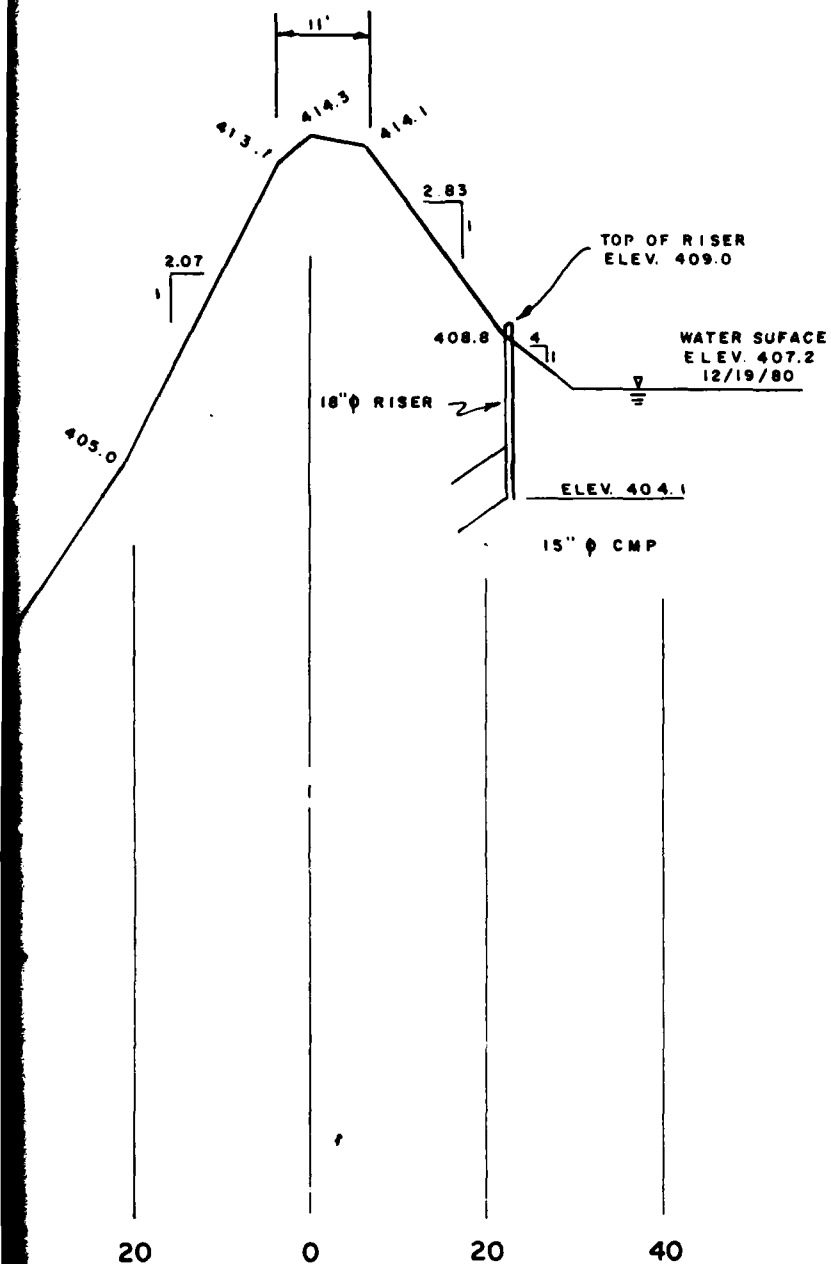


INV. ELEV. 390.5

PLUNGE POOL
ELEV. 384.6



SECTION A -



- 415

- 410

- 405

- 400

- 395

- 390

- 385

SECTION A - A

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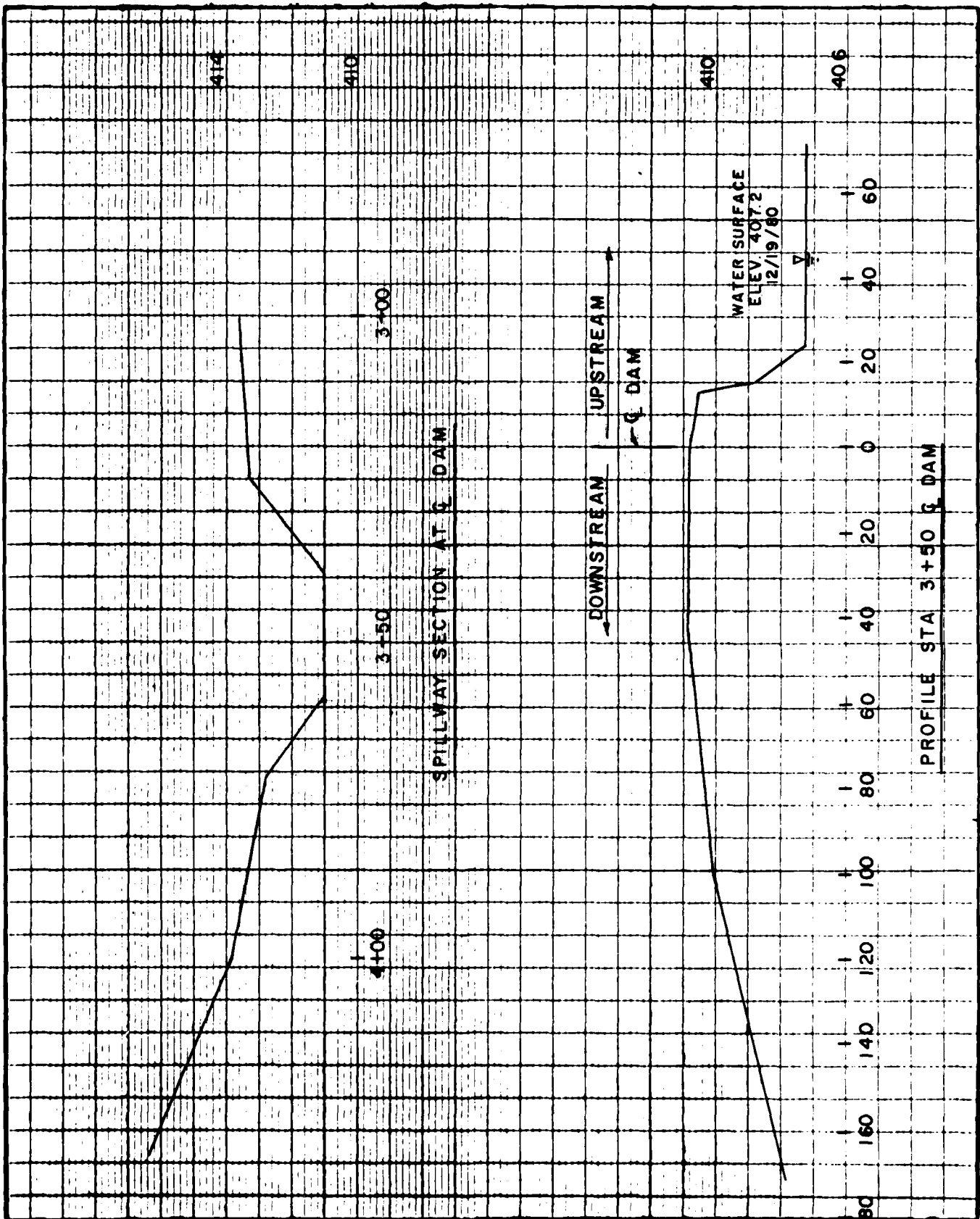
730 N. BENTON AVE. • SPRINGFIELD, MO. 65802

LAKENAN LAKE DAM

MO. No. 31066

PLAN & PROFILE
PERRY COUNTY, MO.

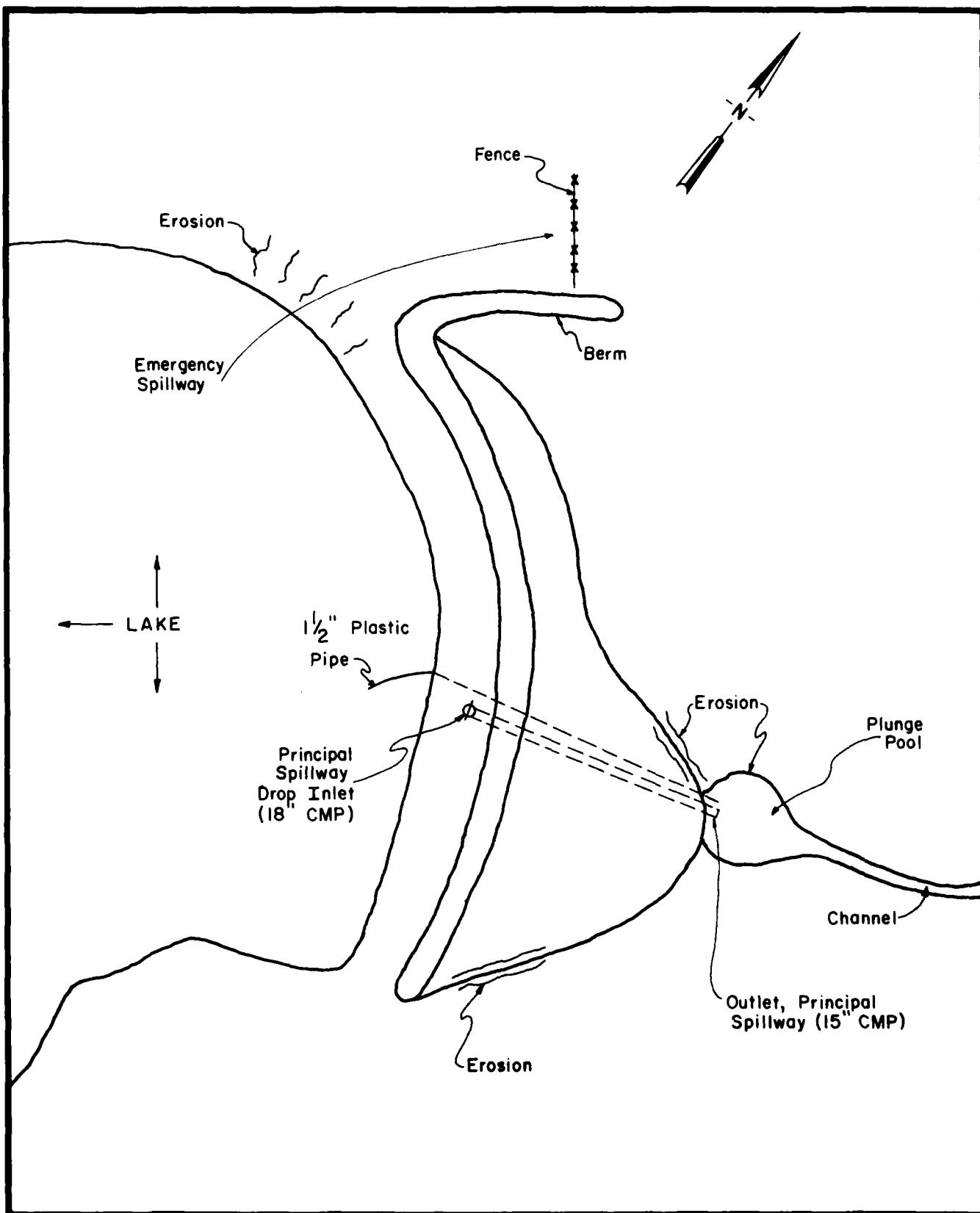
SHEET 3, APPENDIX A



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LAKENAN LAKE DAM
PERRY COUNTY, MISSOURI
MO. I.D. No. 31066
**EMERGENCY SPILLWAY
SECTION & PROFILE**

SHEET 4, APPENDIX A



PLAN SKETCH OF FEATURES



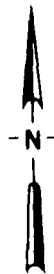
SPRINGFIELD, IL • PEORIA, IL • ROCKFORD, IL

Lakenan Lake Dam
Perry County, Missouri
Mo. I.D. No. 31066

Sheet 5 , Appendix A

APPENDIX B

Geology and Soils



LEGEND

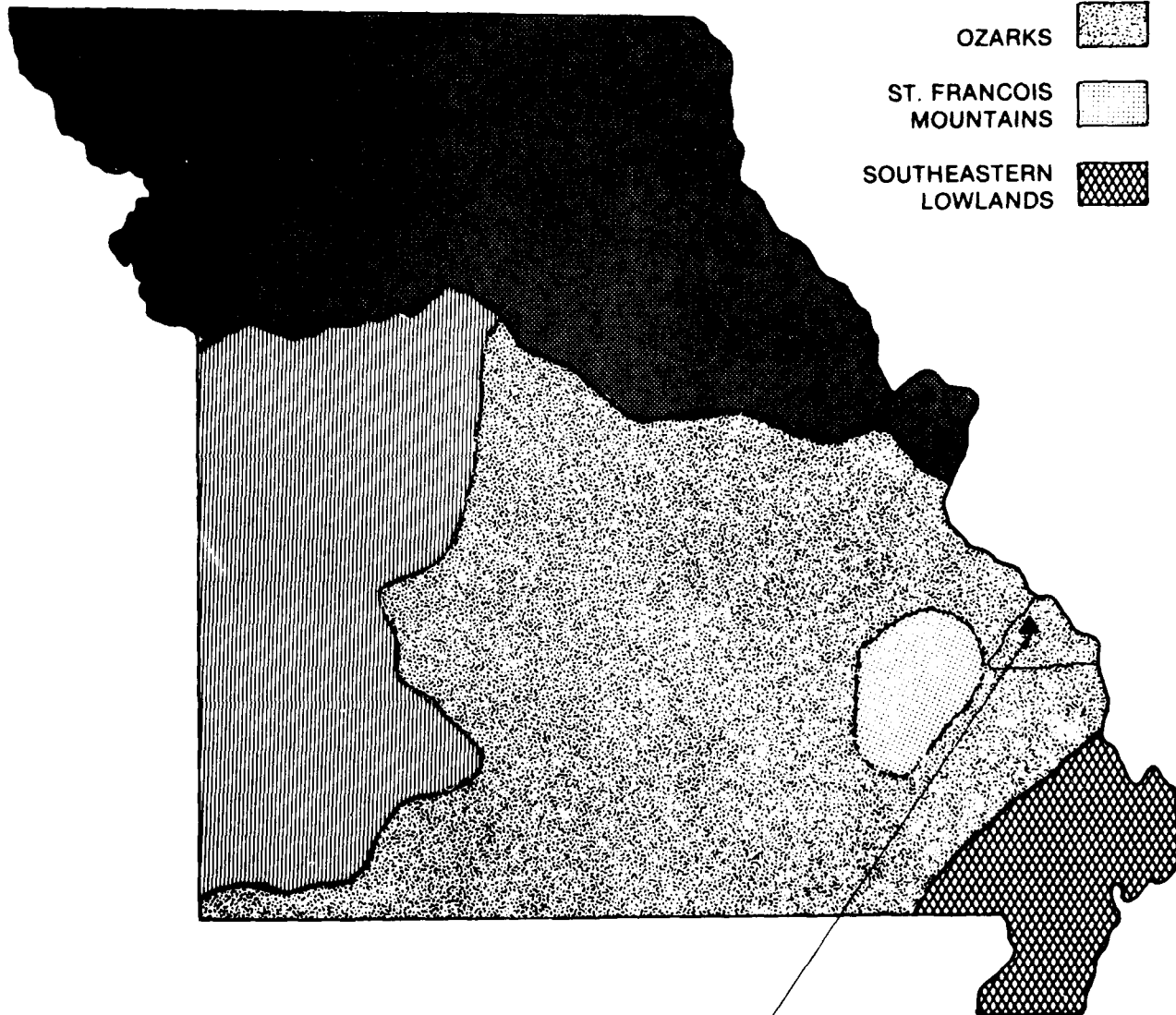
GLACIATED PLAINS 

WESTERN PLAINS 

OZARKS 

ST. FRANCOIS MOUNTAINS 

SOUTHEASTERN LOWLANDS 



Location
of Dam

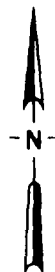
MAJOR GEOLOGIC REGIONS OF MISSOURI



SPRINGFIELD, IL • PEORIA, IL • ROCKFORD, IL

Lakenan Lake Dam
Perry County, Missouri
Mo. I.D. No. 31066

SHEET 1, APPENDIX B



FEET

20 +



10-20



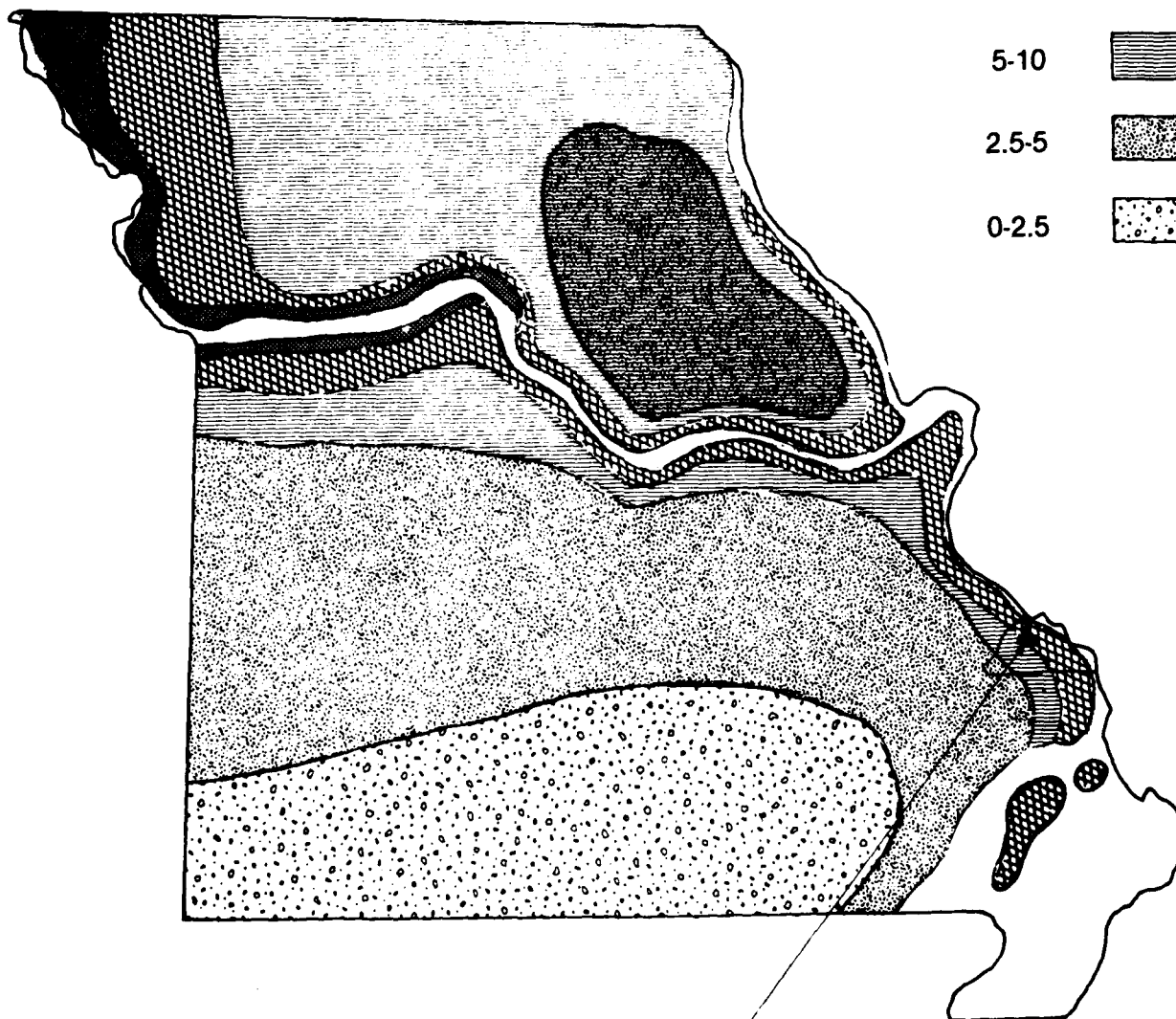
5-10



2.5-5



0-2.5



Location
of Dam

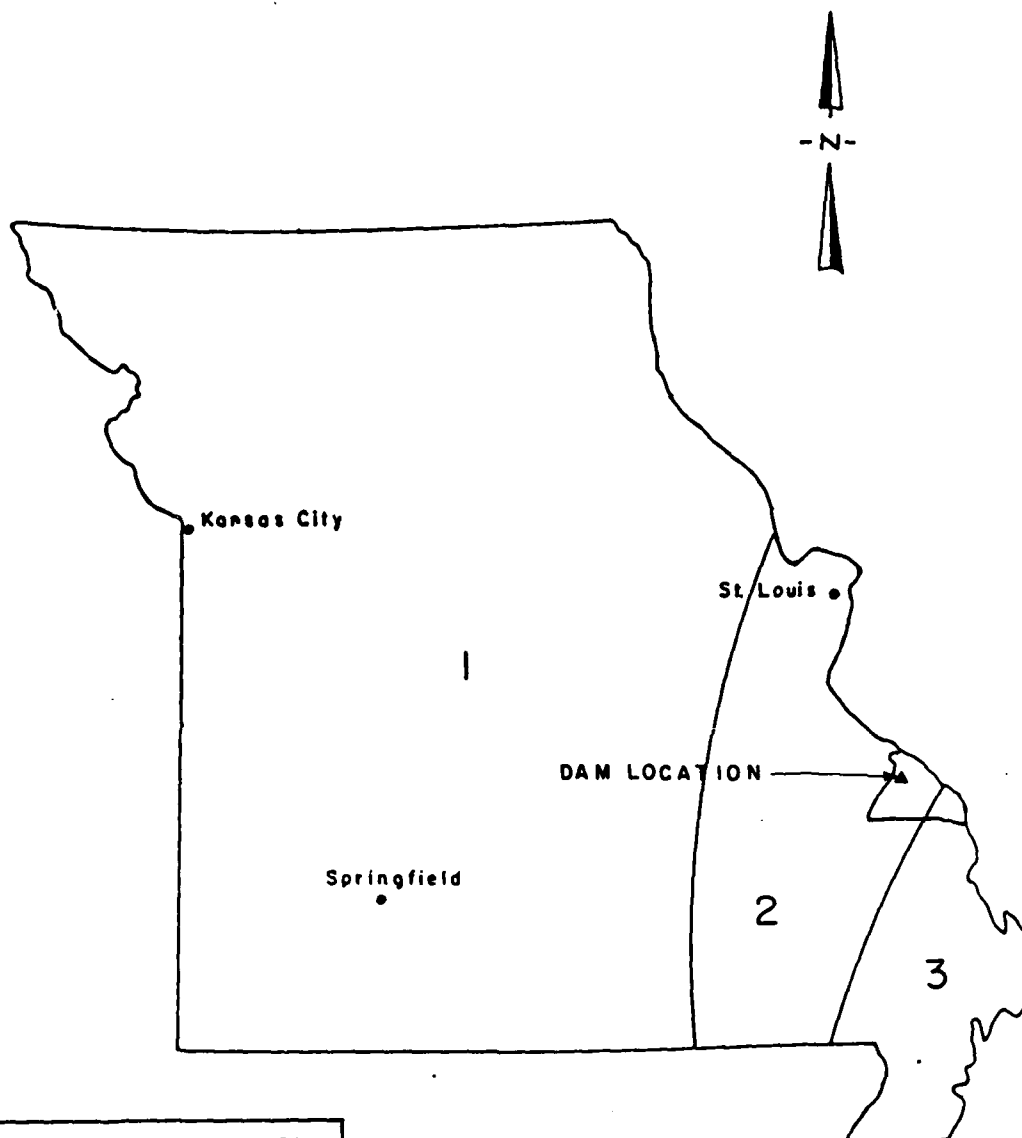
THICKNESS OF LOESSIAL DEPOSITS



SPRINGFIELD, IL • PEORIA, IL • ROCKFORD, IL

Lakenan Lake Dam
Perry County, Missouri
Mo. I.D. No. 31066

SHEET 2, APPENDIX B



SEISMIC PROBABILITY	
ZONE	DAMAGE
1	MINOR
2	MODERATE
3	MAJOR

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SEISMIC ZONE MAP

LAKENAN LAKE DAM
PERRY COUNTY, MISSOURI
MO. I. D. No. 31066

SHEET 3, APPENDIX B

PRELIMINARY GEOLOGIC INVESTIGATION
OF DAM SITES

Watershed Blue Spring Branch watershed unnamed Site no. County Perry State Mo.
Location SE 1/4 SE 1/4 NE 1/4 sec. 14, T.36 N., R.10 E. (Chester Quad.) Site group Structure class Fund class
Nearest post office St. Marys Landowner/operator Lakenan
Drainage area: sq. mi. acres. Purpose(s) of structure
Embankment: Length ft. Height 15-20 ft. Cubic yards Est. storage capacity ac. ft.
This investigation made by: Inspection of surface X Hand auger Test pits Other (specify) seismic
Investigated by: James H. Withins 22 September 1967
Signature and Title Date

Chief, Eng. Geol. Section
Missouri Geological Survey

GENERAL GEOLOGY

Physiographic description eastern Ozarks Geologic formation(s) Joachim Dolomite
Attitude: Strike Dip
Direction of valley axis (downstream) Steepness of abutments: Left percent, Right percent
Material of abutment and valley walls Brown silty clay and silt loam underlain by Joachim Dolomite.

Surficial deposits Dry silt loam underlain by silty clays possibly interbedded with sand lenses in the lower 10 feet. The lower 10 feet is at or above optimum moisture and deep excavation into this could result in slope stability problems. (see seismic logs)
Faults, folds, joints, caverns and slide areas (describe briefly): The perimeter of the lake is encircled by sinkholes and breached sinkholes. Entry gained into one sinkhole indicates that its conduit discharges near the proposed waterline of the lake. Solution enlarged joints, probably dirt filled, are anticipated to be under the valley floor and on the abutment walls.
(See seismic)
Depth to and kind of rock in foundation 18 to 20 feet to Joachim Dolomite (see seismic)

Depth to groundwater Date measured
Leakage problems If bedrock on the right abutment slope is not padded and/or if the foundation bedrock solution cavities are not dirt filled the lake will be a failure. The geologic setting, especially the groundwater environment, and seismic data indicate that the
EMERGENCY SPILLWAY

Best location: Left abutment Right abutment Other
Estimated excavation: Volume yds.; Percent rock ; Suitable for fill? Type
(GC, CL, etc.)
Erodibility of control section Erodibility of exit channel
(high, medium, low or very low) (high, medium, low or very low)

STREAM OR OUTLET CHANNEL

Description: width ft.; Depth ft.; Bed material *D Size of bed material in.
Channel: Scouring Aggrading X Stable ; Banks: Eroding Stable

* Insert 50 or 75

(continued on reverse side)

* subsurface openings are filled with dirt.

BORROW AREAS

No. _____ Location _____ Direction from dam _____ Distance _____ Probable depth _____ Area _____

Cubic yards available _____ Description of material Silt loam and silty clay (ML-CL and CL)
suitable for borrow is present above the proposed waterline. Borrow should not be
taken from the lake.

Description of materials underlying borrow area Joachim Dolomite

_____ Depth to water _____ Are salts or dispersed soils present? _____

.

No. _____ Location _____ Direction from dam _____ Distance _____ Probable depth _____ Area _____

Cubic yards available _____ Description of material _____

Description of materials underlying borrow area _____

_____ Depth to water _____ Are salts or dispersed soils present? _____

SUMMARY OF FINDINGS, INTERPRETATIONS, AND CONCLUSIONS

The extensive presence of sinkholes developed in the Joachim Dolomite belie the chance of success for a lake at this site. Surface and subsurface exposures of the Joachim Dolomite show that the joints are enlarged by solution so that there are vertical passageways up to 2 feet in width. Locally these are enlarged into small caves with sinkhole entrances. These openings are at or above the stream level. However, since this is groundwater recharge area many if not all of these solution enlarged openings have been filled with silt and clay. In addition the high groundwater table has resulted in aggradation of sediments so that the valley at the dam site is being choked with silts and clays. This same geologic process is thought to have also choked the subsurface rock cavities. Therefore the site is considered to have at least a 50-50 chance of success in spite of the active upstream sinkholes and breached downstream sinkholes.

RECOMMENDATIONS FOR FURTHER INVESTIGATIONS

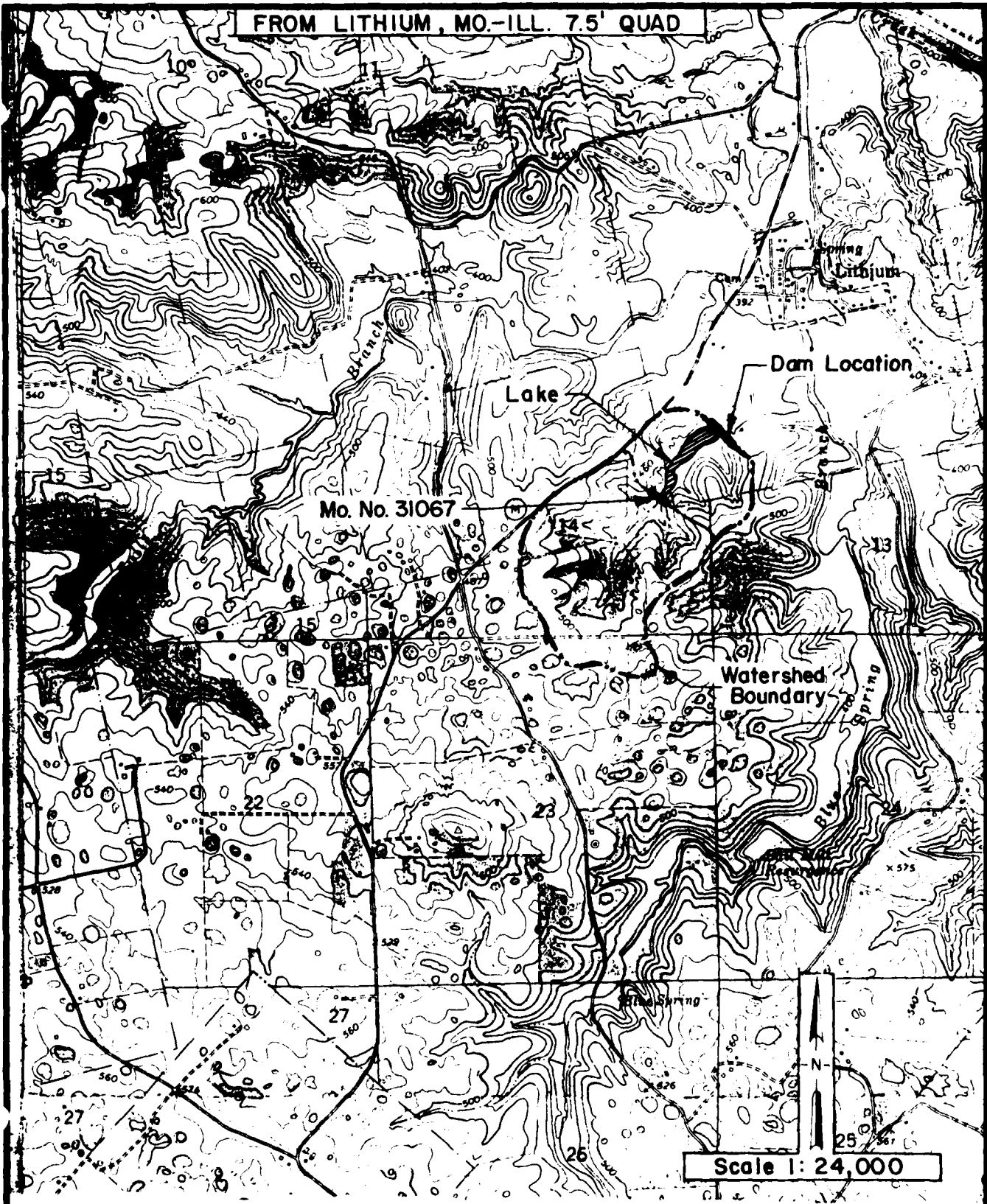
(Including type of equipment required and estimated cost)

Bedrock exposures at the toe of the right abutment may provide channelways for subsurface leakage. It is urged that these exposures should be cleaned of loose surface deposits and sealed by a compacted dirt pad. It is also important that the core trench be ripped into firm fresh bedrock on at least a portion of the right abutment. An upstream pad especially in the stream channel, for a short distance upstream will also be an asset.

APPENDIX C

Overtopping Analysis

FROM LITHIUM, MO.-ILL. 7.5' QUAD



LAKE AND WATERSHED MAP



SPRINGFIELD, IL • PEORIA, IL • ROCKFORD, IL

Lakenan Lake Dam
Perry County, Missouri
Mo. ID. No. 31066

Sheet 1, Appendix C

APPENDIX C

HYDROLOGIC AND HYDRAULIC ANALYSIS

To determine the overtopping potential, flood routings were performed by applying the Probable Maximum Precipitation (PMP) to a synthetic unit hydrograph to develop the inflow hydrograph. The inflow hydrograph was then routed through the reservoir and spillway. The overtopping analysis was accomplished using the systemized computer program HEC-1 (Dam Safety Version), July 1978, prepared by the Hydrologic Engineering Center, U.S. Army Corps of Engineers, Davis, California.

The PMP was determined from regional charts prepared by the National Weather Service in "Hydrometeorological Report No. 33." Reduction factors were not applied. The rainfall distribution for the 24-hour PMP storm duration was assumed according to the procedures outlined in EM 1110-2-1411 (SPD Determination). Also, the 1 percent chance probability flood was routed through the reservoir and spillway. St. Genevieve, Missouri rainfall distribution (5 min. interval - 24 hours duration), as provided by the St. Louis District, Corps of Engineers, was used in this case.

The synthetic unit hydrograph for the watershed was developed by the computer program using the SCS method. The time of concentration was estimated using the Kirpich formula. This formula and the parameters for the unit hydrograph are shown in Table 1 (Sheet 4, Appendix C). The time of concentration was also verified from velocity estimates for the average slopes of the watershed and the main channel (Design of Small Dams, page 70, 1974 Edition).

The SCS curve number (CN) method was used in computing the infiltration losses for rainfall-runoff relationship. The CN values used for the antecedent moisture conditions (AMC), and the result from the computer output, are shown in Table 2 (Sheet 5, Appendix C).

The reservoir routing was accomplished by using the Modified Puls Method assuming the starting lake elevation at normal pool. No antecedent storm was routed in order to determine the starting elevation. It was assumed that the mean annual high water elevation corresponds with the normal pool elevation. The hydraulic capacity of the spillways was used as an outlet control in the routing. The hydraulic capacity of the spillway and the storage capacity of the reservoir were defined by the elevation-surface area-storage-discharge relationships shown in Table 3 (Sheet 5, Appendix C). To consider the effect in the routing analysis of the upper dam (see Section 5 of this report), the routed outflow hydrograph from the upper dam was combined with the inflow hydrograph of the lower dam. Then, the combined hydrograph was routed through the reservoir and spillways of the lower dam. The effect of the upper dam was studied, assuming separately, that the upper dam will resist the overtopping and that the upper dam will breach during overtopping.

The rating curve for the spillways is shown on Table 4 Sheet 6, Appendix C. For the principal spillway, the rating curve was determined assuming pipe entrance control and outlet pipe control. For the emergency spillway, critical flow conditions at the control section, and approach channel losses equal to 30 percent of the velocity head (at the control section) were assumed.

The flow over the crest of the dam during overtopping was determined using the non-level dam option (\$L and \$V cards) of the HEC-1 program. The program assumes critical flow over a broad-crested weir. The lowest elevation of the crest of the dam, obtained from survey measurements, was assumed as top of dam elevation.

A summary of the routing analysis for different ratios of the PMF is shown in Table 5 (Sheet 7, Appendix C). The result of the routings indicates that the spillway will pass the 1 percent probability flood without overtopping the dam.

The computer input data, a summary of the output data, and a plot of the inflow-outflow hydrograph for the PMF, assuming that the upper dam will not breach due to overtopping, are presented on Sheets 8 to 11 of Appendix C. The input and output data for the routing of the PMF, assuming the breach of the upper dam, are shown on Sheets 12, 13, and 14 of Appendix C.

TABLE 1
SYNTHETIC UNIT HYDROGRAPH

Parameters:

Drainage Area (A)	0.09 sq miles (*)
Length of Watercourse (L)	0.25 miles
Difference in elevation (H)	116 feet
Time of concentration (Tc)	0.08 hours
Lag Time (Lg)	0.05 hours
Time to peak (Tp)	0.09 hours
Peak Discharge (Qp)	470 cfs
Duration (D)	5 min.

<u>Time (Min.) (**)</u>	<u>Discharge (cfs) (**)</u>
0	0
5	460
10	176
15	41
20	9
25	2

(*) Drainage area downstream of the upper dam (Total drainage area equal 0.31 square miles)

(**) From the computer output

FORMULA USED:

$$T_c = \left(\frac{11.9 L^3}{H} \right)^{0.385}$$

Kirpich Formula.
From California Culverts Practice, California
Highways and Public Works, September, 1942.

$$L_g = 0.6 T_c$$

$$T_p = \frac{D}{2} + L_g$$

$$Q_p = \frac{484 A \cdot Q}{T_p} \quad Q = \text{Excess Runoff} = 1 \text{ inch}$$

TABLE 2
RAINFALL-RUNOFF VALUES

<u>Selected Storm Event</u>	<u>Storm Duration (Hours)</u>	<u>Rainfall (Inches)</u>	<u>Runoff (Inches)</u>	<u>Loss (Inches)</u>
PMP	24	34.1	31.9	2.2
1% Prob. Flood	24	7.1	3.6	3.5

Additional Data:

- 1) Soil Conservation Service Soil Group B
- 2) Soil Conservation Service Runoff Curve CN = 82 (AMC III) for the PMF
- 3) Soil Conservation Service Runoff Curve CN = 65 (AMC II) for the
1 percent probability flood
- 4) Percentage of Drainage Basin Impervious 11 percent

TABLE 3
ELEVATION, SURFACE AREA, STORAGE AND DISCHARGE RELATIONSHIPS

<u>Elevation (feet-MSL)</u>	<u>Lake Surface Area (acres)</u>	<u>Lake Storage (acre-ft)</u>	<u>Spillway Discharge (cfs)</u>
386.0	0	0	-
*409.0	6.0	69	0
**411.0	7.1	82	15
***413.7	9.5	105	400
415.0	10.6	118	1000
420.0	15.0	182	-

- *Principal spillway crest elevation
 **Emergency spillway crest elevation
 ***Top of dam elevation

The above relationships were developed using data from the SCS plans, the USGS Lithium, MO-IL 7.5 minute quadrangle map with a 20 ft contour interval, and the field measurements.

TABLE 4

SPILLWAYS RATING CURVE

<u>Reservoir Elevation (MSL)</u>	<u>Principal Spillway (cfs)</u>	<u>Emergency Spillway (cfs)</u>	<u>Total Discharge (cfs)</u>
*409.0	0	-	0
410.0	13	-	13
**411.0	15	0	15
412.0	16	65	81
413.0	16	215	231
***413.7	16	384	400
414.0	17	485	502
414.5	17	695	712
414.8	17	865	882
415.6	17	1,400	1,417

*Principal spillway crest elevation

**Emergency spillway crest elevation

***Top of dam elevation

Method Used:

- 1) Principal Spillway: Using charts for corrugated-metal pipes with inlet and outlet control from the U. S. Bureau of Public Roads.
- 2) Emergency Spillway: Assuming critical flow condition at the control section and approach channel losses equal to 30 percent of the velocity head at the control section.

Formula used:

$$\frac{Q^2}{g} = \frac{A^3}{T} \quad \text{Design of Small Dams, Water and Power Resources Service (Former USBR), page 553, 1974 Edition.}$$

Q = Discharge in cubic feet per second

A = Cross sectional area in square feet

T = Water surface width in feet

g = Acceleration of gravity in ft/sec²

TABLE 5
RESULTS OF FLOOD ROUTINGS

Ratio of PMF	Peak Inflow (cfs)	Peak Lake Elevation (ft, MSL)	Total Storage (acre-ft)	Peak Outflow (cfs)	Depth (ft) Over Top of Dam
-	0	*409.0	69	0	-
0.05	86	409.9	75	12	-
0.10	188	411.6	87	57	-
0.15	343	412.4	94	141	-
0.20	508	413.2	101	274	-
0.25	688	413.8	106	441	0.1
0.30	896	414.2	110	668	0.5
0.50	1,800	414.9	117	1,630	1.2
0.75	2,940	415.4	123	2,665	1.7
1.00	4,040	415.9	129	3,670	2.2

The percentage of the PMF that will reach the top of the dam is about 25 percent.

*Principal spillway crest elevation
Top of dam elevation = 413.7

A OVERTOPPING ANALYSIS FOR LAKEMAN LAKE DAM (# 4)
 A STATE ID NO. 31066 COUNTY NAME : PERRY
 A HANSON ENGINEERS INC. DAM SAFETY INSPECTION JOB # 81S3001
 B 288 5
 B1 5
 J 1 9 1
 J1 .05 .10 .15 .20 .25 .30 .50 .75 1.0
 K 0 1 3 1
 K1 INFLOW HYDROGRAPH COMPUTATION FOR ELLIS LAKE DAM
 M 1 2 .22 .22 1 1
 P 0 26.2 102 120 130
 T -1 -78 0.03
 W2 0.17 0.10
 X 0 -.1 2
 K 1 2 0 4 1
 K1 RESERVOIR ROUTING BY MODIFIED PULS AT DAM SITE (ELLIS LAKE DAM)
 Y 1 1
 Y1 1 45 -1
 Y4 427.0 428.0 429.0 430.2 431.0 431.5 432.0 432.5 433.0 433.5
 Y4 434.0 434.5
 Y5 0 2 3 3 34 79 150 244 355 485
 Y5 635 825
 \$\$ 0 21 45 59 71 97
 \$E 406.0 420.0 427.0 430.2 432.0 435.0
 \$\$ 427.0
 \$D 432.0
 \$L 0 27 100 180 210 324 327 330 337
 \$V 431.7 432.0 432.5 433.0 433.2 433.4 433.6 434.0 434.8
 K 0 3 3 1
 K1 INFLOW HYDROGRAPH COMPUTATION FOR LAKEMAN LAKE DAM
 M 1 2 0.09 0.09 1 1
 P 0 26.2 102 120 130
 T -1 -82 0.111
 W2 .084 0.05
 X 0 -.1 2
 K 2 4 3 1
 K1 COMBINE OUTFLOW HYDROGRAPH FROM ELLIS LAKE AND INFLOW HYDR.FOR LAKEMAN LAKE
 K 1 5 0 4 1
 K1 RESERVOIR ROUTING BY MODIFIED PULS AT LAKEMAN LAKE DAM SITE **
 Y 1 1
 Y1 1 69 -1
 Y4 409.0 410.0 411.0 412.0 413.0 413.7 414.0 414.5 414.8 415.6
 Y5 0 13 15 81 231 400 502 712 882 1417
 \$\$ 0 69 82 105 118 182
 \$E 386.0 409.0 411.0 413.7 415.0 420.0
 \$\$ 409.0
 \$D 413.7
 \$L 0 10 105 175 200 250 260 287 292
 \$V 413.6 413.7 413.9 414.1 414.3 414.3 414.6 415.3 416.0
 K 99

PMF RATIOS
 INPUT DATA
 ASSUMING NO BREACH OF THE UPPER DAM

PEAK FLOW AND STORAGE (END OF PERIOD) SUMMARY FOR MULTIPLE PLAN-RATIO ECONOMIC COMPUTATIONS
 FLOWS IN CUBIC FEET PER SECOND (CUBIC METERS PER SECOND)
 AREA IN SQUARE MILES (SQUARE KILOMETERS)

OPERATION	STATION	AREA	PLAN	RATIOS APPLIED TO FLOWS								
				RATIO 1	RATIO 2	RATIO 3	RATIO 4	RATIO 5	RATIO 6	RATIO 7	RATIO 8	RATIO 9
				0.05	0.10	0.15	0.20	0.25	0.30	0.50	0.75	1.00
HYDROGRAPH AT	1	0.22	1	159.	318.	478.	637.	796.	955.	1592.	2388.	3183.
	(	0.57)	(	4.51)	9.01)	13.52)	18.03)	22.54)	27.04)	45.07)	67.61)	90.15)
ROUTED TO	2	0.22	1	11.	76.	215.	364.	523.	689.	1333.	2117.	2946.
	(	0.57)	(	0.32)	2.16)	6.08)	10.32)	14.80)	19.51)	37.74)	59.96)	83.41)
HYDROGRAPH AT	3	0.09	1	83.	165.	248.	331.	413.	496.	827.	1240.	1653.
	(	0.23)	(	2.34)	4.68)	7.02)	9.36)	11.70)	14.04)	23.41)	35.11)	46.81)
2 COMBINED	4	0.31	1	86.	188.	343.	508.	688.	896.	1797.	2940.	4043.
	(	0.80)	(	2.43)	5.34)	9.72)	14.38)	19.48)	25.37)	50.88)	83.26)	114.48)
ROUTED TO	5	0.31	1	12.	57.	141.	274.	441.	668.	1634.	2665.	3668.
	(	0.80)	(	0.34)	1.61)	3.98)	7.76)	12.49)	18.91)	46.28)	75.45)	103.86)

SUMMARY OF DAM SAFETY ANALYSIS

PMF RATIOS
 OUTPUT DATA (1-2)
 ASSUMING NO BREACH OF THE
 UPPER DAM

UPPER DAM

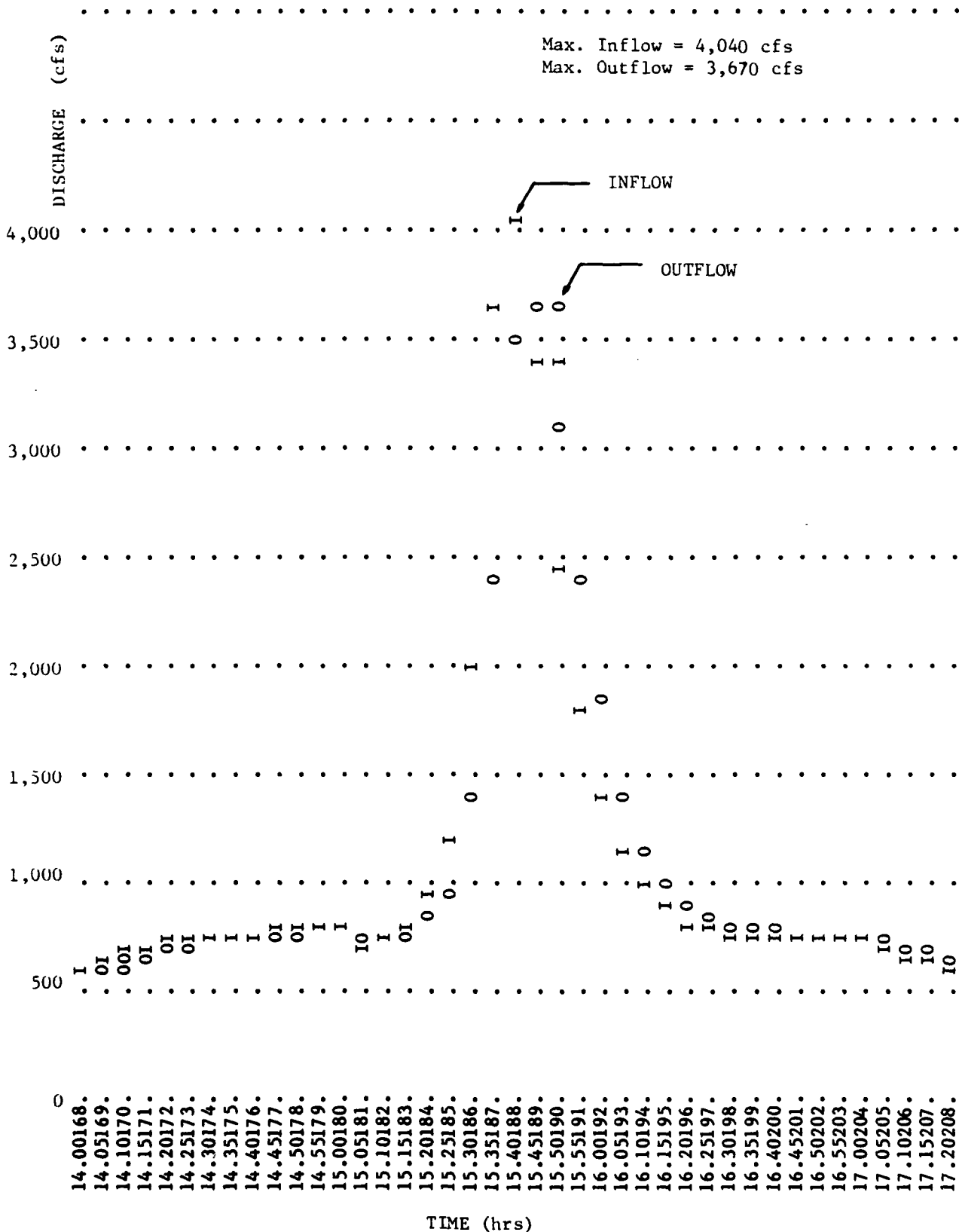
RATIO OF PMF	MAXIMUM RESERVOIR W.S.ELEV	INITIAL VALUE		SPILLWAY CREST		TOP OF DAM		TIME OF FAILURE HOURS
		MAXIMUM DEPTH OVER DAM	MAXIMUM STORAGE AC-FT	MAXIMUM OUTFLOW CFS	DURATION OVER TOP HOURS	MAX OUTFLOW HOURS		
0.05	430.41	0.00	60.	11.	0.00	18.50	0.00	
0.10	431.47	0.00	67.	76.	0.00	16.08	0.00	
0.15	432.22	0.22	73.	215.	0.50	15.83	0.00	
0.20	432.59	0.59	76.	364.	1.00	15.83	0.00	
0.25	432.85	0.85	78.	523.	1.42	15.75	0.00	
0.30	433.06	1.06	80.	689.	2.00	15.75	0.00	
0.50	433.59	1.59	85.	1333.	5.25	15.75	0.00	
0.75	434.03	2.03	89.	2117.	6.50	15.67	0.00	
1.00	434.41	2.41	92.	2946.	7.08	15.67	0.00	
SUMMARY OF DAM SAFETY ANALYSIS								

SUMMARY OF DAM SAFETY ANALYSIS

LAKEMAN LAKE DAM

LAKE DAM		ELEVATION		INITIAL VALUE		SPILLWAY CREST		TOP OF DAM		TIME OF FAILURE	
RATIO OF PMF	MAXIMUM RESERVOIR W.S.ELEV	MAXIMUM DEPTH OVER DAM	MAXIMUM STORAGE AC-FT	MAXIMUM OUTFLOW CFS	DURATION OVER TOP HOURS	MAX OUTFLOW HOURS	TIME OF FAILURE HOURS	MAX OUTFLOW HOURS	TIME OF FAILURE HOURS	TIME OF FAILURE HOURS	TIME OF FAILURE HOURS
0.05	409.92	0.00	75.	12.	0.00	19.50	0.00	409.00	413.70	0.00	0.00
0.10	411.63	0.00	87.	57.	0.00	18.25	0.00	69.	105.	0.00	0.00
0.15	412.40	0.00	94.	141.	0.00	16.75	0.00	0.	400.	0.00	0.00
0.20	413.18	0.00	101.	274.	0.00	16.17	0.00			0.00	0.00
0.25	413.81	0.11	106.	441.	0.33	16.00	0.00			0.00	0.00
0.30	414.17	0.47	110.	668.	0.67	15.92	0.00			0.00	0.00
0.50	414.89	1.19	117.	1634.	1.67	15.75	0.00			0.00	0.00
0.75	415.41	1.71	123.	2665.	4.50	15.75	0.00			0.00	0.00
1.00	415.85	2.15	129.	3668.	5.58	15.75	0.00			0.00	0.00

PMF RATIOS
OUTPUT DATA (2-2)
ASSUMING NO BREACH OF THE
UPPER DAM



INFLOW - OUTFLOW HYDROGRAPH
FOR THE PMF

A OVERTOPPING ANALYSIS FOR LAKEMAN LAKE DAM (# 4) (BREACH ANALYSIS)
A STATE ID NO. 31066 COUNTY NAME : PERRY
A HANSON ENGINEERS INC. DAM SAFETY INSPECTION JOB # 81S3001

B 288 5
B1 5
J 2 1 1
J1 1.0
K 0 1 5 1
K1 INFLOW HYDROGRAPH COMPUTATION FOR ELLIS LAKE DAM
M 1 2 .22 .22 1 1
P 0 26.2 102 120 130
T -1 -78 0.03

W2 0.17 0.10
X 0 -.1 2
K 1 2 0 5 1
K1 RESERVOIR ROUTING BY MODIFIED PULS AT DAM SITE (ELLIS LAKE DAM)

Y 1 1 1
Y1 1 45 -1
Y4 427.0 428.0 429.0 430.2 431.0 431.5 432.0 432.5 433.0 433.5
Y4 434.0 434.5
Y5 0 2 3 3 34 79 150 244 355 485
Y5 635 825
\$S 0 21 45 59 71 97
\$E 406.0 420.0 427.0 430.2 432.0 435.0
\$\$ 427.0
\$D 432.0
\$S 0 27 100 180 210 324 327 330 337
\$V 431.7 432.0 432.5 433.0 433.2 433.4 433.6 434.0 434.8
\$B 10 0.5 412.0 .50 427.0 434.40
\$B 10 0.5 412.0 1.0 427.0 434.40
K 0 3 5 1

K1 INFLOW HYDROGRAPH COMPUTATION FOR LAKEMAN LAKE DAM
M 1 2 0.09 0.09 1 1
P 0 26.2 102 120 130
T -1 -82 0.11

W2 .084 0.05
X 0 -.1 2
K 2 4 5 1

K1 COMBINE OUTFLOW HYDROGRAPH FROM ELLIS LAKE AND INFLOW HYDR.FOR LAKEMAN LAKE
K 1 5 0 5 1
K1 RESERVOIR ROUTING BY MODIFIED PULS AT LAKEMAN LAKE DAM SITE **

Y 1 1 1
Y1 1 69 -1
Y4 409.0 410.0 411.0 412.0 413.0 413.7 414.0 414.5 414.8 415.6
Y5 0 13 15 81 231 400 502 712 882 1417
\$S 0 69 82 105 118 182
\$E 386.0 409.0 411.0 413.7 415.0 420.0
\$\$ 409.0
\$D 413.7
\$S 0 10 105 175 200 250 260 287 292
\$V 413.6 413.7 413.9 414.1 414.3 414.3 414.6 415.3 416.0
K 99

PMF RATIOS
INPUT DATA
ASSUMING BREACH OF UPPER DAM

PEAK FLOW AND STORAGE (END OF PERIOD) SUMMARY FOR MULTIPLE PLAN-RATIO ECONOMIC COMPUTATIONS
 FLOWS IN CUBIC FEET PER SECOND (CUBIC METERS PER SECOND)
 AREA IN SQUARE MILES (SQUARE KILOMETERS)

OPERATION	STATION	AREA	RATIOS APPLIED TO FLOWS	
			PLAN	RATIO 1
				1.00
HYDROGRAPH AT	1	0.22	1	3183.
	(	0.57)	(	90.15)(
	2		2	3183.
	(		(	90.15)(
ROUTED TO	2	0.22	1	3054.
	(	0.57)	(	86.48)(
	2		2	2946.
	(		(	83.41)(
HYDROGRAPH AT	3	0.09	1	1653.
	(	0.23)	(	46.81)(
	2		2	1653.
	(		(	46.81)(
2 COMBINED	4	0.31	1	4043.
	(	0.80)	(	114.49)(
	2		2	4043.
	(		(	114.49)(
ROUTED TO	5	0.31	1	3488.
	(	0.80)	(	98.77)(
	2		2	3488.
	(		(	98.77)(

SUMMARY OF DAM SAFETY ANALYSIS

PMF OUTPUT DATA (1-2)
 ASSUMING BREACH OF THE UPPER DAM

SUMMARY OF DAM SAFETY ANALYSIS

UPPER DAM

Failure Time = 0.5 hr

RATIO OF PMF	MAXIMUM RESERVOIR W.S.ELEV	INITIAL VALUE		SPILLWAY CREST		TOP OF DAM		TIME OF FAILURE HOURS
		MAXIMUM DEPTH OVER DAM	MAXIMUM STORAGE AC-FT	MAXIMUM OUTFLOW CFS	DURATION OVER TOP HOURS	MAX OUTFLOW HOURS		
1.00	435.42	3.42	101.	3110.	3.78	16.10	15.67	

Failure Time = 1.0 hr

ELEVATION	INITIAL VALUE	SPILLWAY CREST	TOP OF DAM
STORAGE	427.00	427.00	432.00
OUTFLOW	45.	45.	71.
	0.	0.	150.

SUMMARY OF DAM SAFETY ANALYSIS

LAKEMAN LAKE DAM

Failure Time = 0.5 hr

ELEVATION	INITIAL VALUE	SPILLWAY CREST	TOP OF DAM
STORAGE	409.00	409.00	413.70
OUTFLOW	69.	69.	105.
	0.	0.	400.

Failure Time = 1.0 hr

RATIO OF PMF	MAXIMUM RESERVOIR W.S.ELEV	INITIAL VALUE		SPILLWAY CREST		TOP OF DAM		TIME OF FAILURE HOURS
		MAXIMUM DEPTH OVER DAM	MAXIMUM STORAGE AC-FT	MAXIMUM OUTFLOW CFS	DURATION OVER TOP HOURS	MAX OUTFLOW HOURS	TIME OF FAILURE HOURS	
1.00	415.77	2.07	128.	3488.	5.58	15.67	0.00	

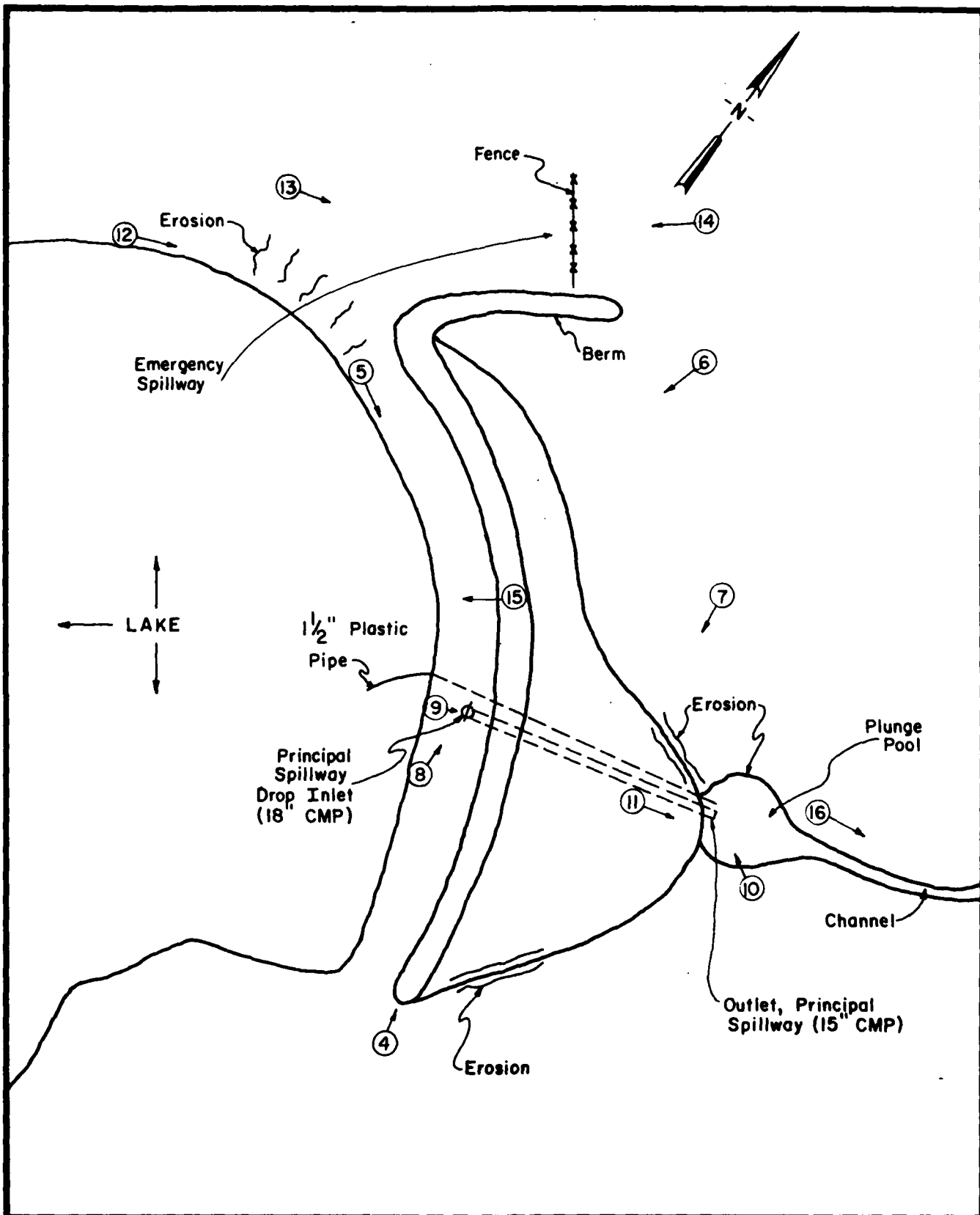
PMF OUTPUT DATA (2-2)
ASSUMING BREACH OF THE UPPER DAM

APPENDIX D

Photographs

LIST OF PHOTOGRAPHS

<u>Photo No.</u>	<u>Description</u>
1.	Aerial View of Dams 31067 and 31066 looking northeast (Village of Lithium in Upper Left)
2.	Aerial view of dam and lake looking southwest.
3.	Aerial view of dam looking northwest.
4.	Crest of dam looking northwest from right abutment.
5.	Upstream face of dam looking southeast from left abutment area.
6.	Left portion of downstream face of dam looking south from left abutment area.
7.	Downstream face of dam looking from left abutment area.
8.	Principal spillway drop inlet.
9.	Principal spillway drop inlet.
10.	Outlet pipe of principal spillway, note outlet of plastic watering pipe at bottom of photograph.
11.	Plunge pool of principal spillway looking downstream.
12.	Emergency spillway approach area, note erosion.
13.	Emergency spillway looking downstream from left side.
14.	Emergency spillway looking downstream.
15.	Lake area looking from crest of embankment, note plastic watering pipe in foreground.
16.	Downstream area looking from crest of embankment, downstream channel on right.



PHOTOGRAPH LOCATIONS

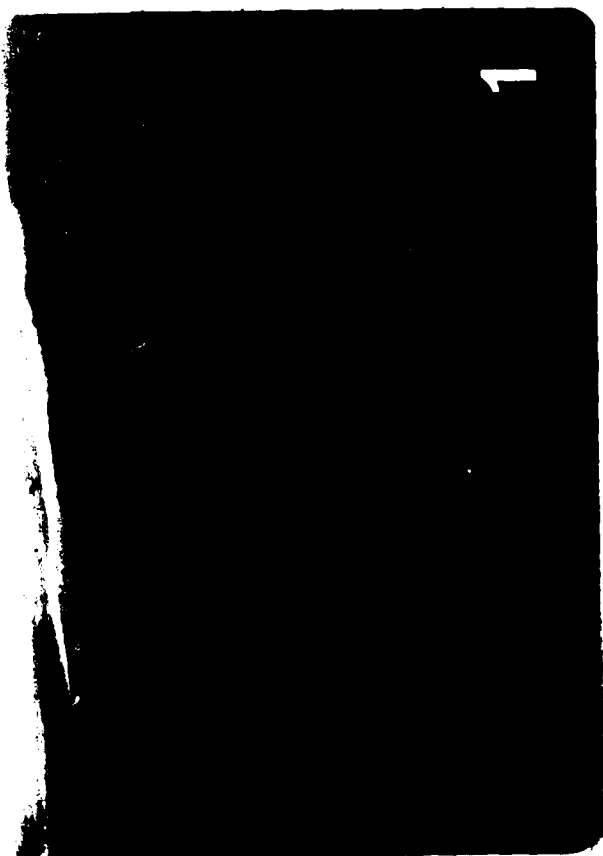


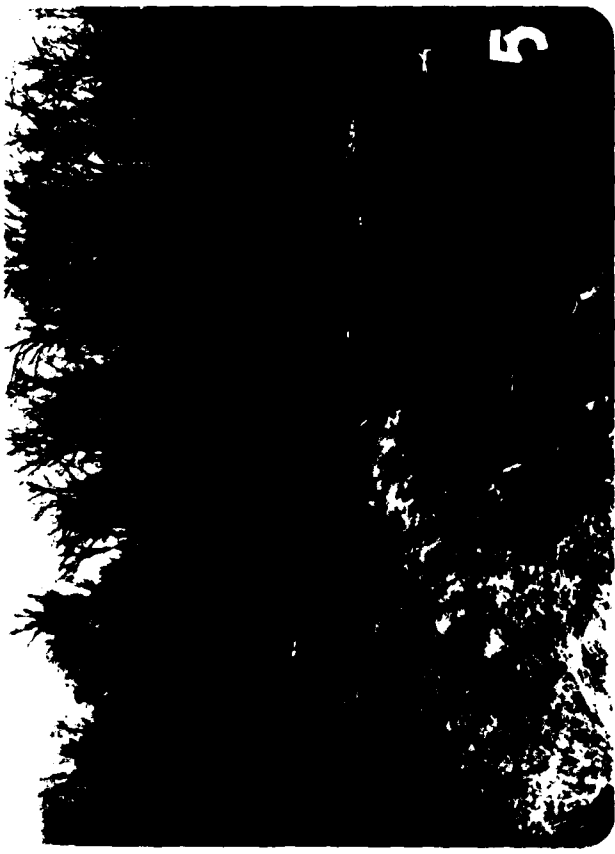
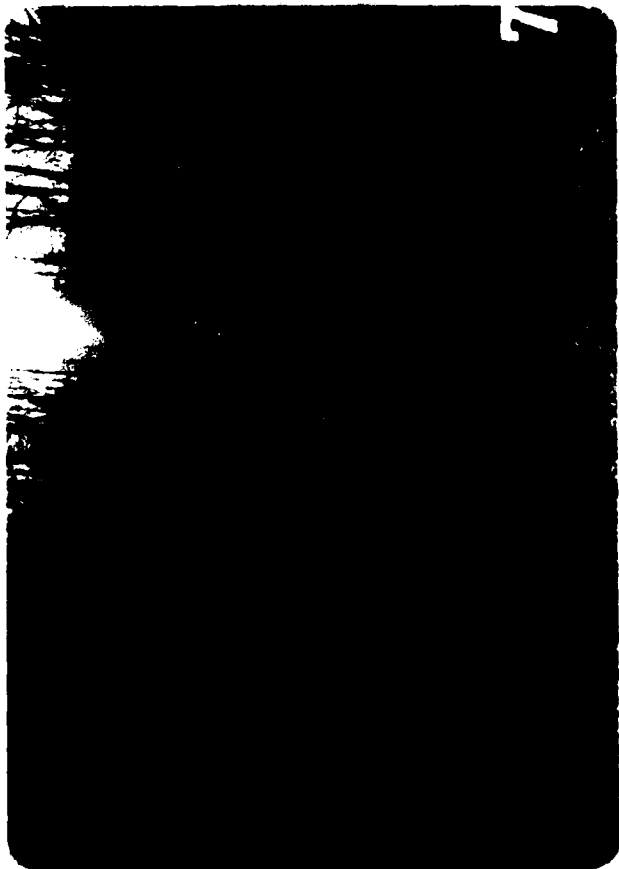
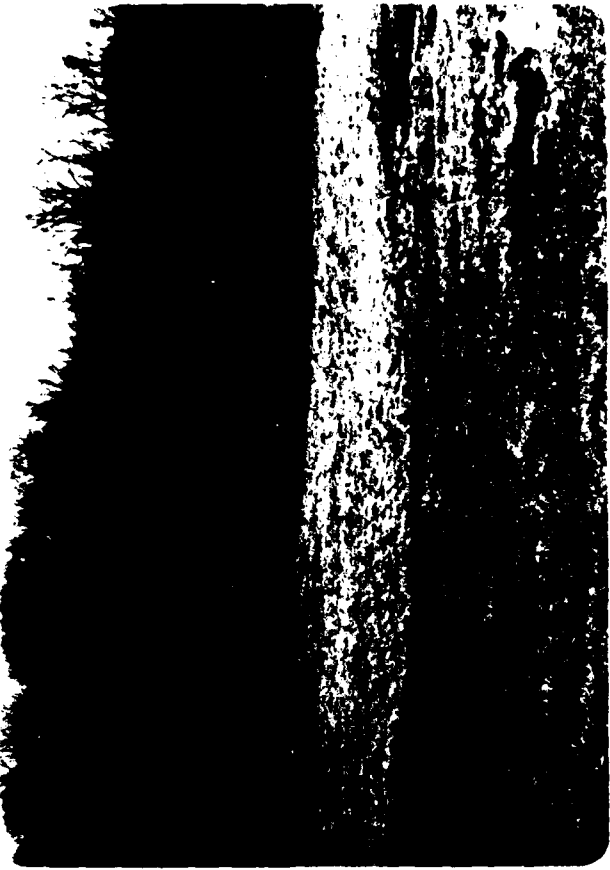
HANSON
ENGINEERS
INCORPORATED

SPRINGFIELD, IL • PEORIA, IL • ROCKFORD, IL

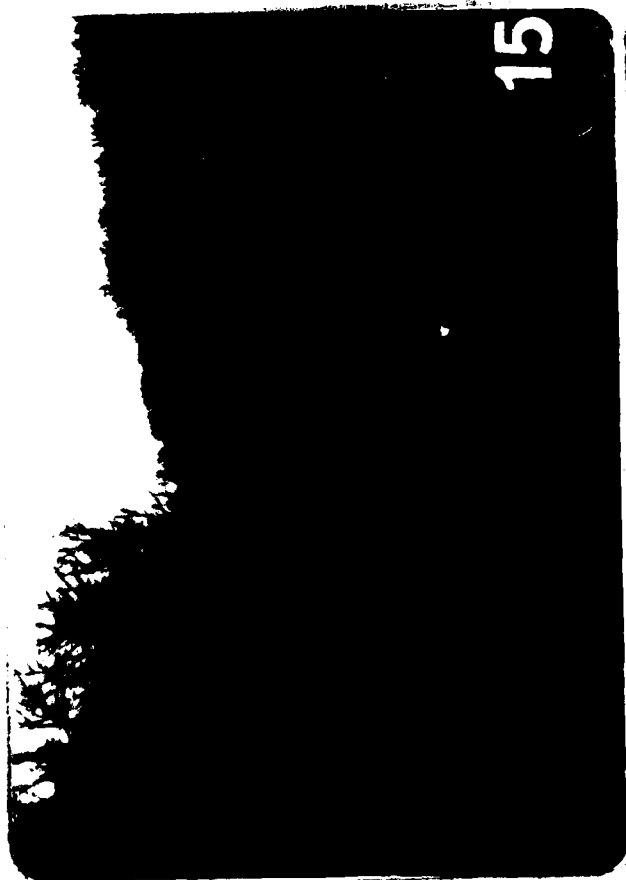
Lakenan Lake Dam
Perry County, Missouri
Mo. I.D. No. 31066

Sheet 2, Appendix D









END
DATE
ILME